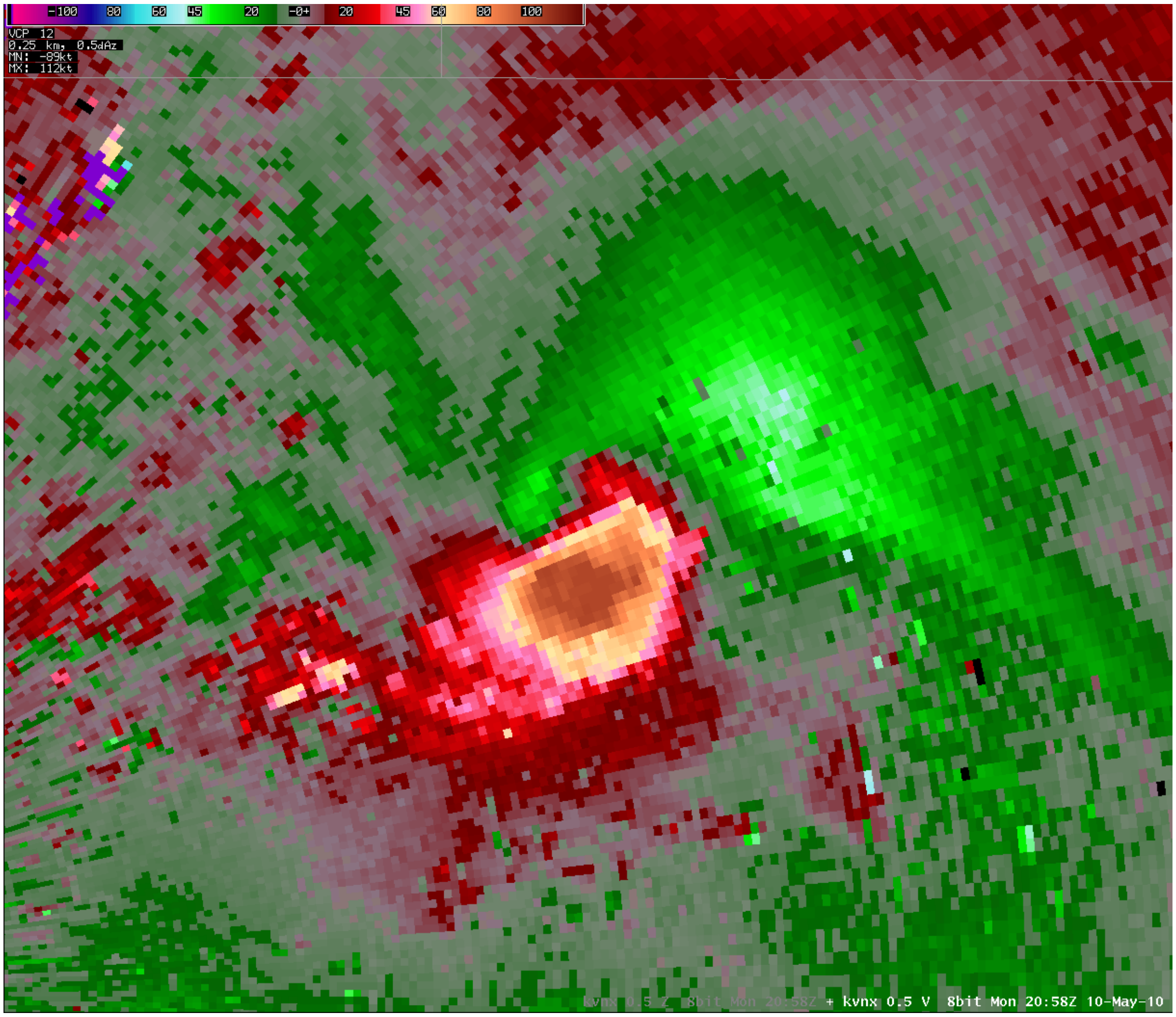
Distance Learning Operations Course



Topic 4: Velocity Interpretation

Presented by the Warning Decision Training Branch

Version: 0910

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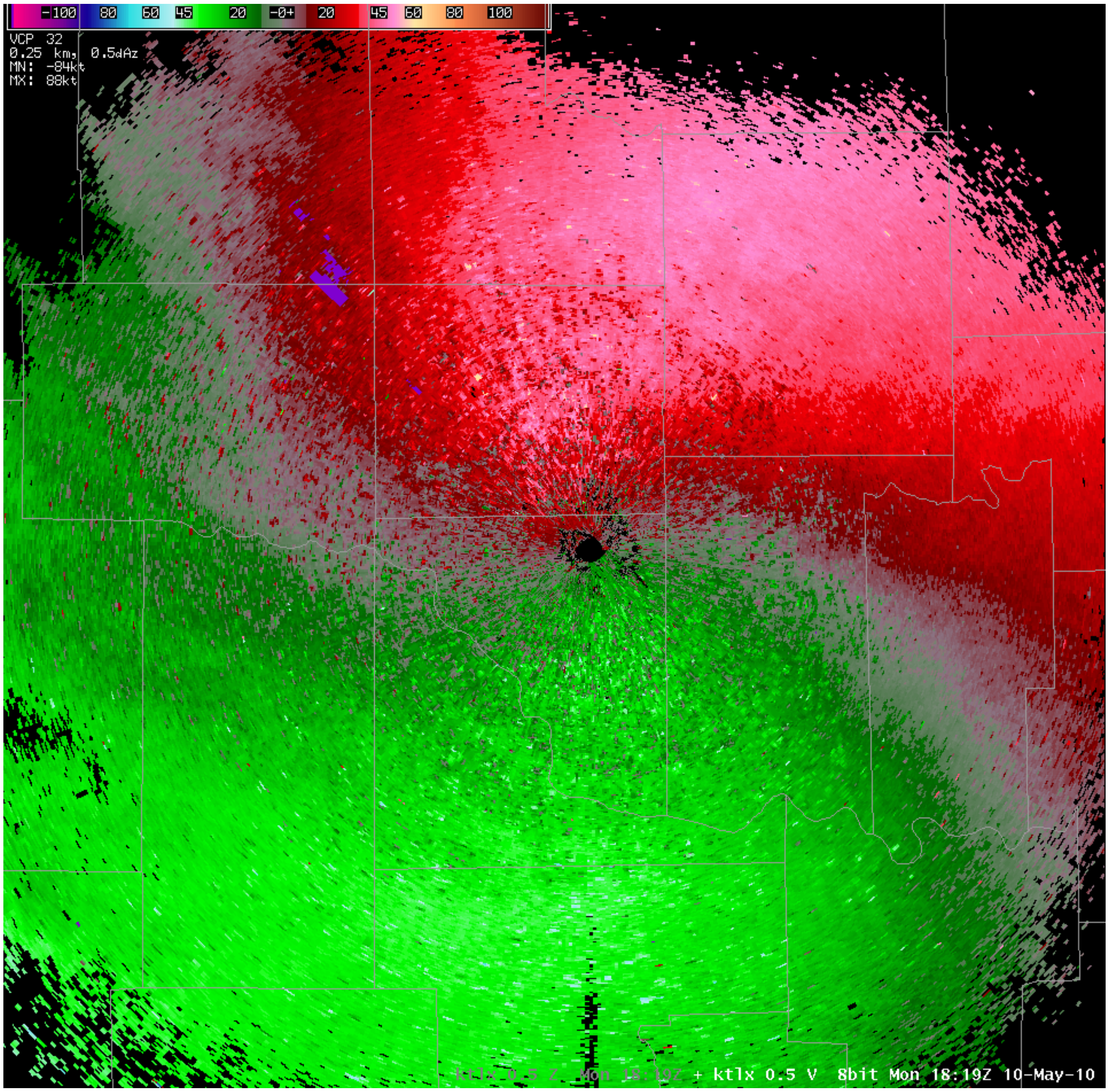


Lesson 1: Large-Scale Doppler Velocity Patterns

Presented by the Warning Decision Training Branch

Version: 0910

Lesson 1: Large-Scale Doppler Velocity Patterns

Review from Topic 3

1. When interpreting velocity products, ***radial*** velocities are displayed, which are ***not*** the true velocities.

2. Improperly dealiased velocities and range folding ***can*** inhibit velocity interpretation.

Overview

In this lesson, you will learn:

- The basic principles used to identify radial velocity signatures.
- How velocity displays relate to the vertical wind profile.
- How to use velocity interpretation principles with WSR-88D velocity products.

Objectives

Without references, and in accordance with the lesson, you will be able to:

1. Interpret Doppler velocity patterns under uniform, non-uniform, ambiguous, and meteorologically complex conditions identifying:

a. Inbound vs. Outbound Flow

b. Velocity Data Level Intervals

c. Constant Wind Speed and Direction

d. Wind Speed and Direction Changing with Height

e. Velocity Maxima

f. Confluence and Diffluence

g. Vertical Discontinuities

h. Boundaries

2. Construct vertical wind profiles for uniform and non-uniform horizontal wind conditions.

3. Assess the meteorological conditions associated with the identified velocity patterns.

Introduction

In this lesson, we will interpret large scale velocity signatures from both clear air and widespread precipitation events. Lesson 2 will focus on velocity signatures associated with convective storms.

Velocity Display

When looking at a velocity product, you are viewing the display from above looking into a cone (Figure 4-1).

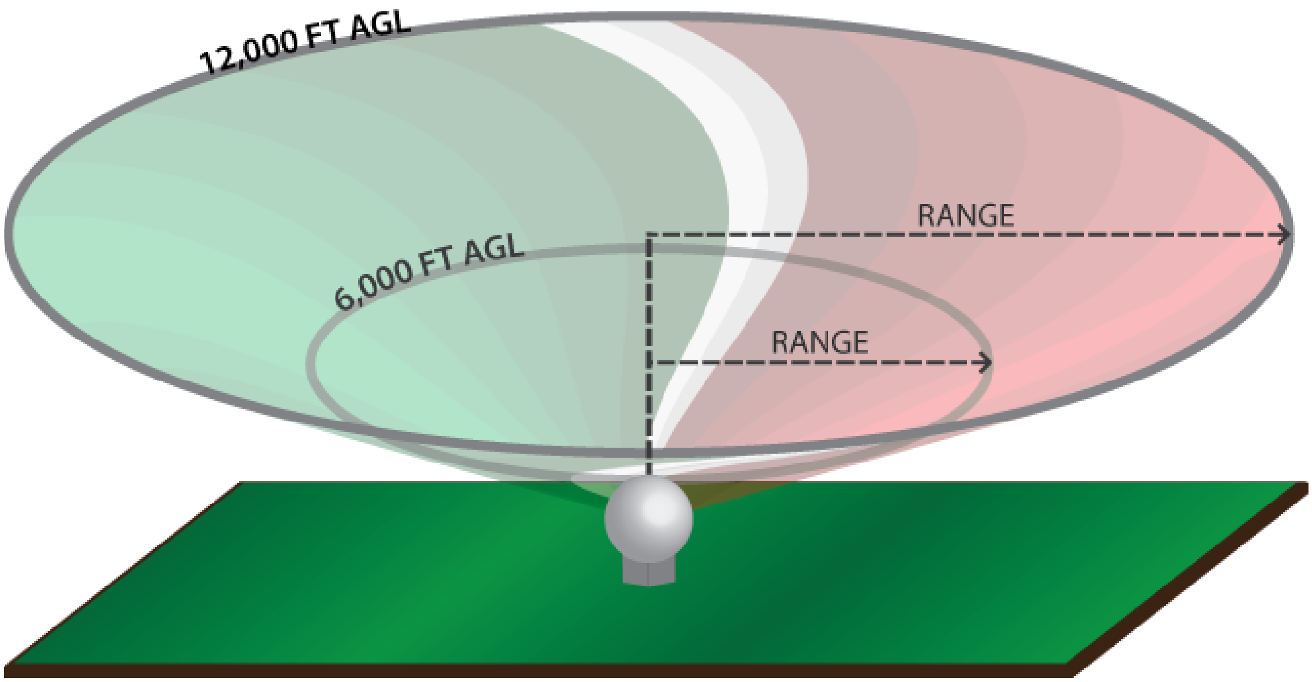


Figure 4-1. The slant range on the edge of the display corresponds to a height above the ground.

It is important to note that as you move away from the RDA, you are also moving up in height. Using this concept, we can infer a three-dimensional wind field from a single elevation angle velocity product (Figure 4-2).

When viewing a velocity product, you are actually viewing a 3-D wind flow on a 2-D display. At an AWIPS workstation, hold down the left mouse button at a selected cursor location. This will display the height in feet (AGL/MSL), azimuth (degrees) range (statute miles), and radial velocity (knots).

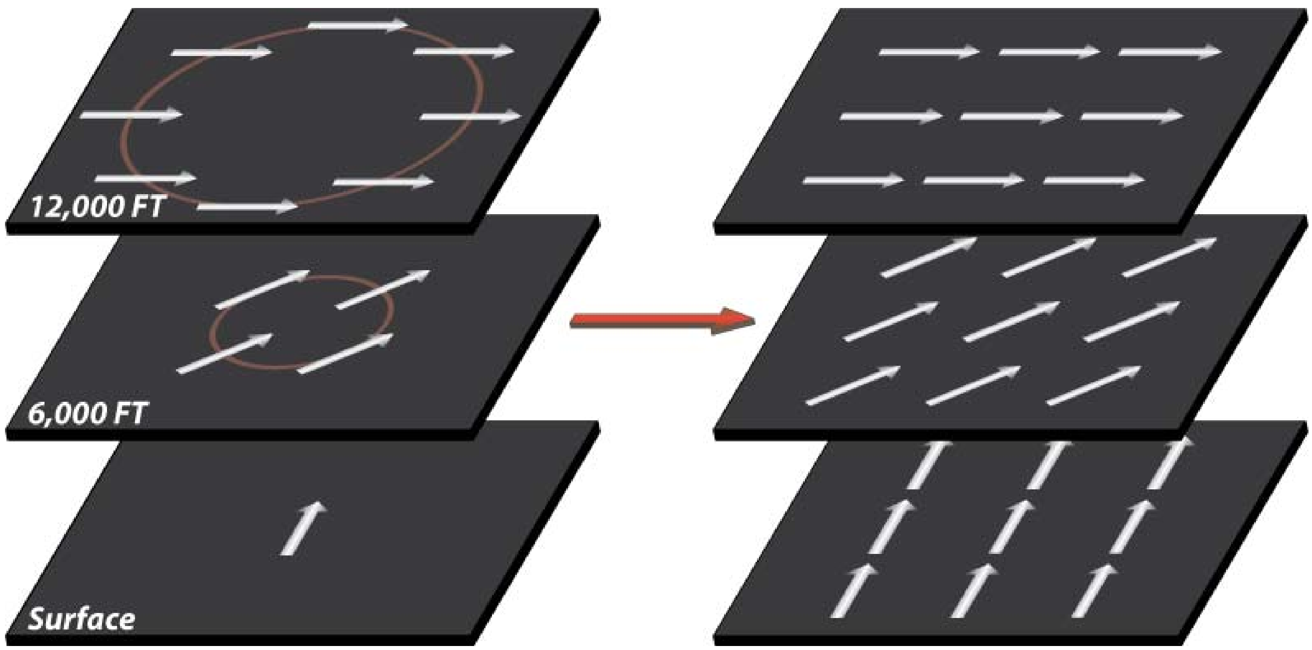


Figure 4-2. Three-dimensional flow from Doppler radar data.

Radial Velocities

Radial velocity (V_r) is defined as the component of target motion ***parallel*** to the radar radial (azimuth). It is that component of a target's actual velocity (V) that is either ***toward*** or ***away*** from the radar site along the radial (see Figures 4-3 and 4-4).

Some important principles to remember about Doppler radial velocity are:

1. Radial velocities will always be ***less than or equal to*** actual target velocities.

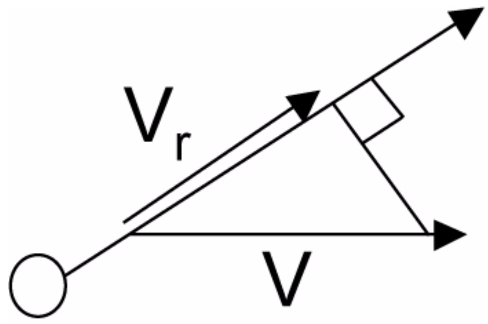


Figure 4-3. Radial velocity illustration.

2. Radial velocity equals actual velocity ***only*** where target motion is ***directly toward*** or ***away from*** the radar.

3. ***Zero velocity*** is measured where target motion is ***perpendicular*** to a radial or where the target is stationary.

The Relation of Actual Velocity to Radial Velocity

When sampling large-scale atmospheric flow, most of what is depicted will be less than the actual environmental flow. The same holds true even for storm-scale rotational flows since only that component of a circulation either directly toward or away from the radar will have its actual velocity detected.

Radial Velocity Equation

The relationship between a target's actual velocity and the WSR-88D depicted radial velocity can be described mathematically by using the Radial Velocity Equation

$$|\boldsymbol{V_r}| = |\boldsymbol{V}| \cdot \cos\beta \tag{1}$$

where

- $\boldsymbol{V_r}$ = radial velocity
- $\boldsymbol{V}$ = actual velocity
- β = smaller angle between **V** and the radar radial
- cos = cosine

The Angle β

The angle β (beta) is ***always the smaller*** of the two angles between the radar viewing angle (i.e. radar radial or azimuth) and the actual target velocity vector (***V***).

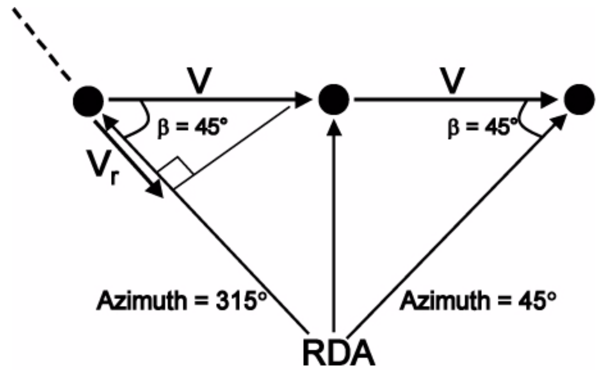


Figure 4-4. As target motion becomes more (less) perpendicular to the radar beam, β increases (decreases). When the target motion is exactly perpendicular to the radar beam, β is 90°, and the radial velocity is zero.

β is Equal to 0°

When β is equal to 0°, target motion is parallel to the radar beam, and cos β is 1. The target radial speed ($|V_r|$) is equal to the actual target speed ($|V|$).

β is Equal to 90°

When β is equal to 90°, target motion is perpendicular to the radar beam, and cos β is zero. The radial speed ($|V_r|$) is zero, and there is no component of target motion toward or away from the radar.

Radial Velocity Computation Example

Assume that the actual wind is uniform from a direction of 300° at 30 knots through the lower atmosphere (Figure 4-5).

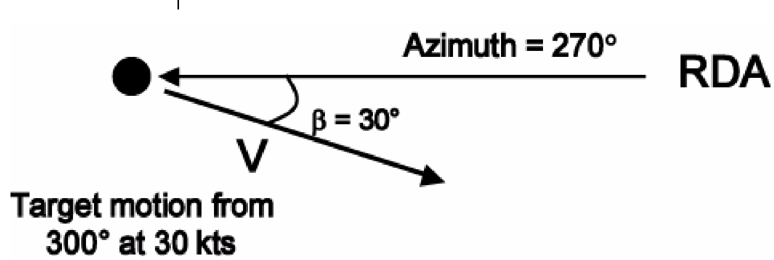


Figure 4-5. Radial speed computation example.

As the antenna is pointed due west (along the 270° radial), a radial wind speed of 26 knots would be measured. This answer is obtained by using equation (1) and $\beta = 30°$ (Figure 4-5).

$$|\mathbf{V_r}| = |\mathbf{V}| \cos \beta$$

$$|\mathbf{V_r}| = (30 \text{ kt}) \quad \cos (30°)$$

$$|\mathbf{V_r}| = (30 \text{ kt}) (.866)$$

$$|\mathbf{V_r}| = \quad 25.98 \text{ kt} \approx 26 \text{ kt}$$

Target Direction

Once the speed is calculated from equation (1), the direction, either toward or away from the RDA, must be determined. This is simply the direction of the component of the actual wind that lies along the radial. In Figure 4-5, the radial component, $\mathbf{V_r}$, would be towards the RDA (defined as inbound velocities). Thus, the radial velocity is -26 knots.

The reason that inbound velocities (cool colors) are negative and outbound velocities (warm colors) are positive is that the first Doppler radars pointed straight up, so downdrafts (negative vertical motion) pointed toward the radar. ***Always*** refer to the color scale associated with that product before you attempt to interpret the product.

Figure 4-6 shows how equation (1) comes from trigonometry, where the actual wind vector and the components along and perpendicular to the radar radial form a right triangle. Also in Figure 4-6, the actual wind is southerly over the display. A radar azimuth has been selected in each quadrant and the actual wind vector has been decomposed into components along and perpendicular to the radial. Although the magnitudes differ, note that the radial velocities in the two southern quadrants are inbound and in the two northern quadrants are outbound.

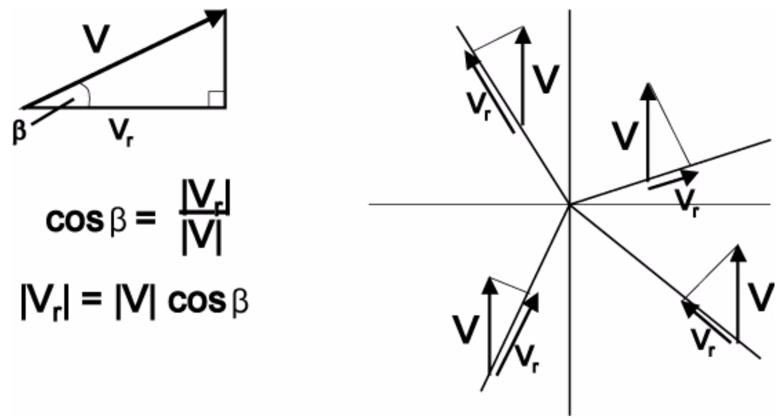


Figure 4-6. Determining the direction of the radial component of the actual velocity.

Relationship Between β and Percentage of Actual Velocity

The ***greater*** the angle between the target's velocity vector and the radar azimuth, the ***smaller*** the percentage of the target's actual velocity that will be measured and depicted on the velocity products. Table 1 shows the relationship between β and the percentage of actual target speed that is directly measured. It is not a linear relationship because of the cosine function. For example, a β of 45° (halfway between 0° and 90°) results in a radial speed that is approximately 70% of the actual speed, not 50%.

Table 1: Percentage of Target Speed Measured

β degrees	Cosine β	Percent Measured
0	1	100
5	.996	99.6
10	.985	98.5
15	.966	96.6
30	.866	86.6
45	.707	70.7
60	.500	50.0
75	.259	25.9
90	0	0

Figure 4-7 depicts the radar's ability to measure velocities and what the operator sees in a homogeneous westerly flow. When the wind is parallel to the radial, the full component of the wind is measured. As the radial becomes more perpendicular to the actual wind, the radial component decreases. When the radial is perpendicular to the wind, the radar displays zero velocity. However, the actual velocity has not changed. This is the reason that the colors change or speed seems to decrease as you move away from the actual wind direction/speed (e.g., Figure 4-8).

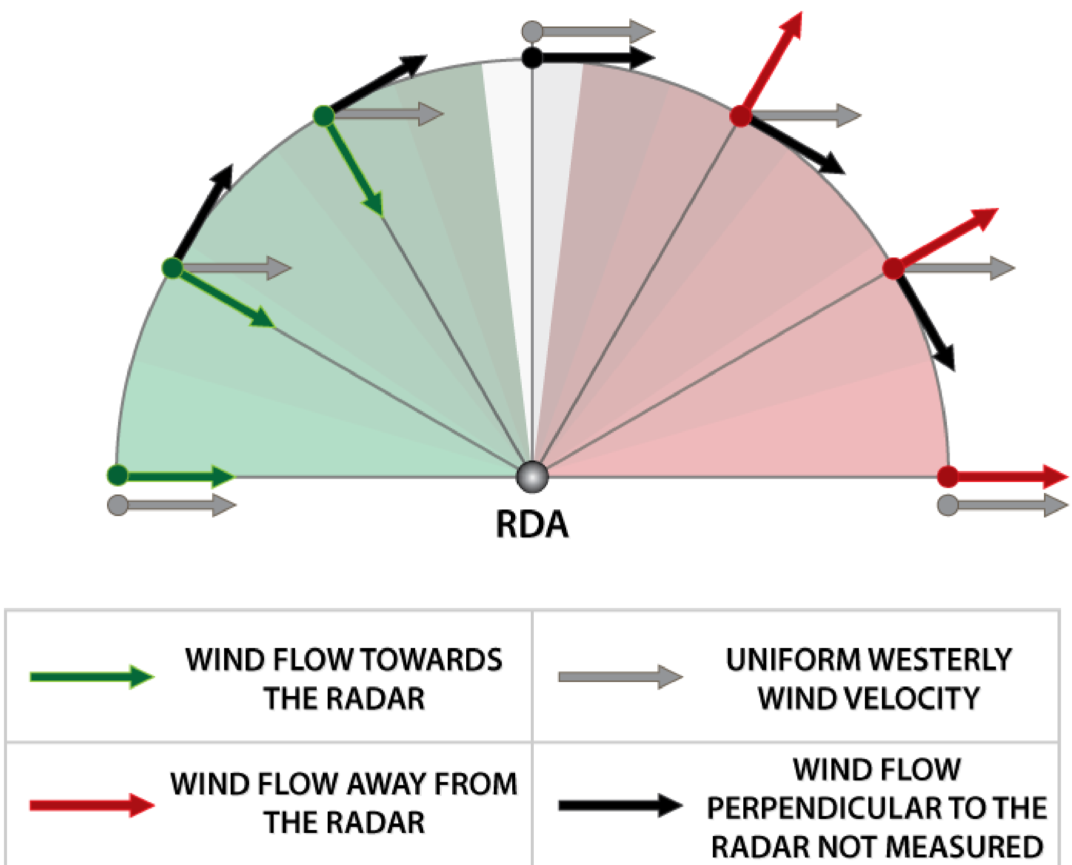


Figure 4-7. In this figure, the gray arrows depict the actual velocity, and the green/red arrows depict the component of velocity measured along the radial. The black arrows depict the component of velocity perpendicular to the radial, which the WSR-88D does not detect.

Definitions At this point in time, it is important to define some terms.

Zero Velocity — Doppler (radial) velocity where the actual speed is zero, ***or*** the direction is perpendicular to the beam.

Isodop — An isodop is a line of ***constant Doppler (radial) velocity.***

Zero Isodop — A zero isodop is a line of ***constant zero Doppler (radial) velocity.***

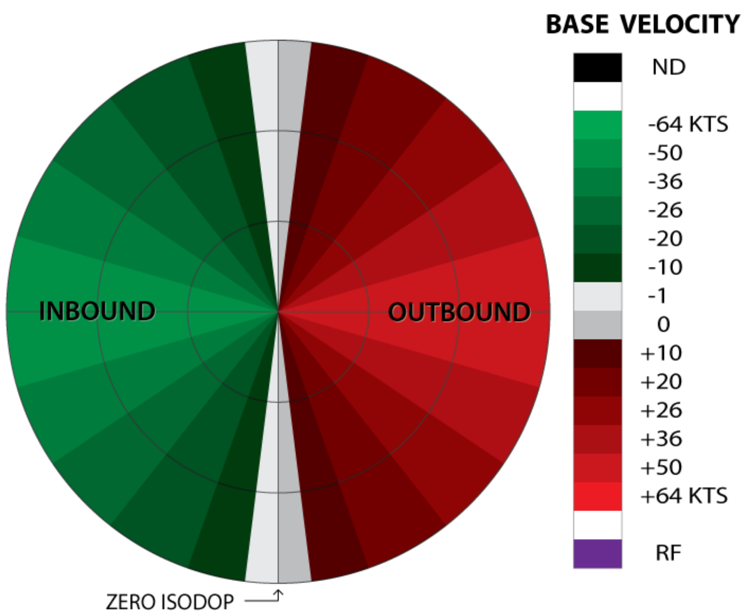


Figure 4-8. Radial velocity pattern for homogeneous westerly flow.

Direction The zero isodop is used to determine wind direction. A zero isodop with inbound velocities on one side and outbound on the other normally indicates wind perpendicular to the radar beam.

A straight zero isodop across the display will normally indicate ***uniformly directional flow*** at all levels.

Determining Direction Using the Zero Isodop

We have a method to use the zero isodop to help determine wind ***direction*** when it is changing with height.

1. Draw a line along a radial from the RDA to some point on the zero isodop.

2. At this point, draw an arrow ***perpendicular to the line along the radial.*** Point this arrow from inbound to outbound.

3. Assuming homogeneous flow, the arrow represents the ***wind direction at that range (height).***

or

Maximum Inbound/Outbound

In cases with good sample coverage, you can also use the maximum inbound/outbound velocities at a constant range (height) to determine direction.

There will be many cases when one of the methods outlined above will not work. At times, the operator will have to use a combination of the two methods.

Speed

Wind speed at a particular range (height) is determined by the highest Doppler velocity at that range if in a homogeneous flow field. The highest Doppler velocities can normally be found about $\pm 90^{\circ}$ from the zero isodop.

Zero Isodop Example

By using the zero isodop method described previously, we can determine the wind direction at any range (or height). It is very important to draw the arrows ***perpendicular to the line from the RDA (radial), not the zero isodop*** itself. Figure 4-9 shows the lines drawn out from the RDA and the arrows which indicate the direction. Figure 4-10 shows the computed wind field over the entire display based on the analysis of the zero isodop.

Note that all the computer-generated patterns have the center at the RDA. With regards to the range rings shown in these computer-generated images, the first range ring indicating the low-level velocities. The second range ring indicates the mid-level velocities, and the edge of the display indicates the high-level velocities. When viewing the range rings in D2D, note the range of each ring from the RDA and the average elevation of each range ring.

Constant Direction With Height

In Figure 4-11, the zero isodop is a straight white line across the display. A straight zero isodop indicates uniform direction. In this case, the wind direction is uniformly west to east from the surface out to the edge of the display. Note that this example has isodops that all converge at the RDA. This indicates that the wind speeds are also uniform. For any given range (height), the same maximum inbound and outbound values are encountered.

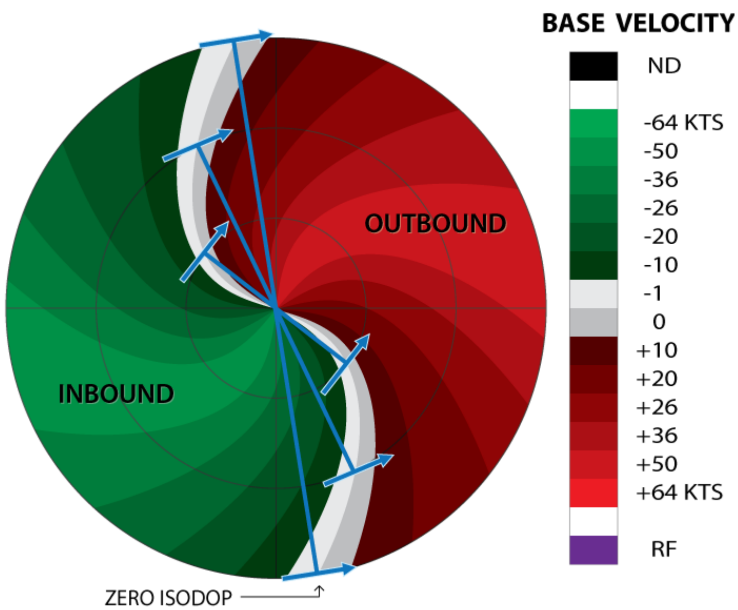


Figure 4-9. Draw a line from the RDA to the zero isodop. Then draw an arrow perpendicular to the radar radial at that point.

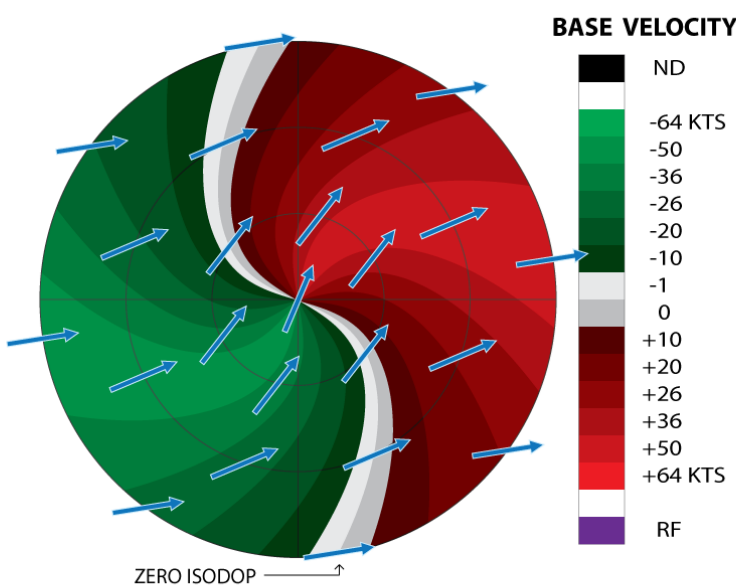


Figure 4-10. Arrows depicting the flow at each range ring.

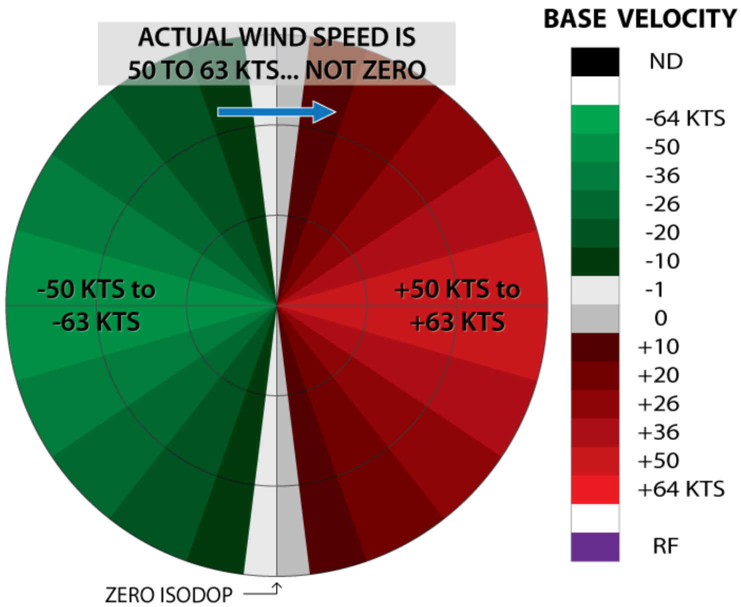


Figure 4-11. Radial velocity pattern for homogeneous westerly flow. Note the straight zero isodop indicating uniform direction and the isodops converging at the RDA indicating uniform speed.

Wind Maximum

A wind maximum is identified by closed isodops surrounding a maximum velocity value. Figure 4-12 shows closed isodops indicating velocity maxima between the first and second range rings (from west to east). Greater than zero isodops are also converging at the RDA. Note that the wind speeds decrease as you approach the edge of the display with calm winds at the height corresponding to the edge.

Figure 4-13 is a WSR-88D example of a relatively straight zero isodop, which is oriented from east to west. It also has a low-level wind maximum with lighter winds surrounding the maximum. The low-level winds are approximately 15 kts near the RDA while increasing up to 30-35 kts as you move farther away. However, the velocities begin to decrease as you continue to radially move away from the RDA.

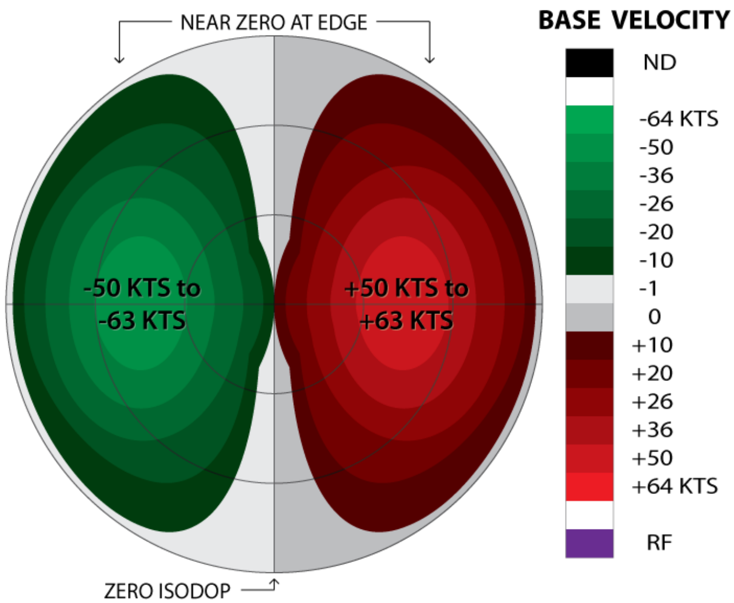


Figure 4-12. Radial velocity pattern for a wind speed maximum aloft. Note the closed isodops to the west and east of the RDA.

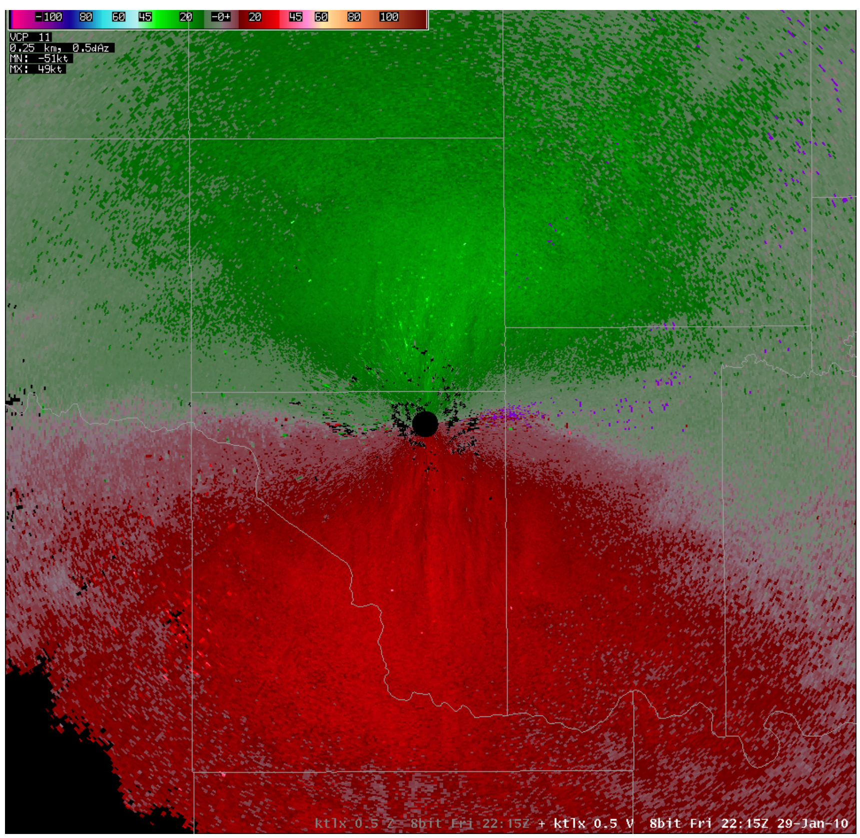


Figure 4-13. Example velocity image with a straight zero isodop and wind speed maximum aloft.

"S" Shape

Curvature of the zero isodop represents a changing wind direction with height. Figure 4-14 has a "S" shape to the zero isodop. The direction changes from the south at the RDA to the southwest at the first range ring to the west at the edge of the display. The speed is constant at 36-49 kts from the surface up to the maximum displayed elevation. The associated vertical wind profile indicates that the winds are turning clockwise with height. The meteorological term for this is ***veering***. Veering typically indicates that warm air advection is occurring.

Figure 4-15 is a real world example of veering winds with height. There is a "S" shape to the zero isodop with winds changing direction from the north-northeast at the RDA to the south at the edge of the display. Thus, the winds are veering with height through the layer. Also note that there is a wind maximum in the lower layers.

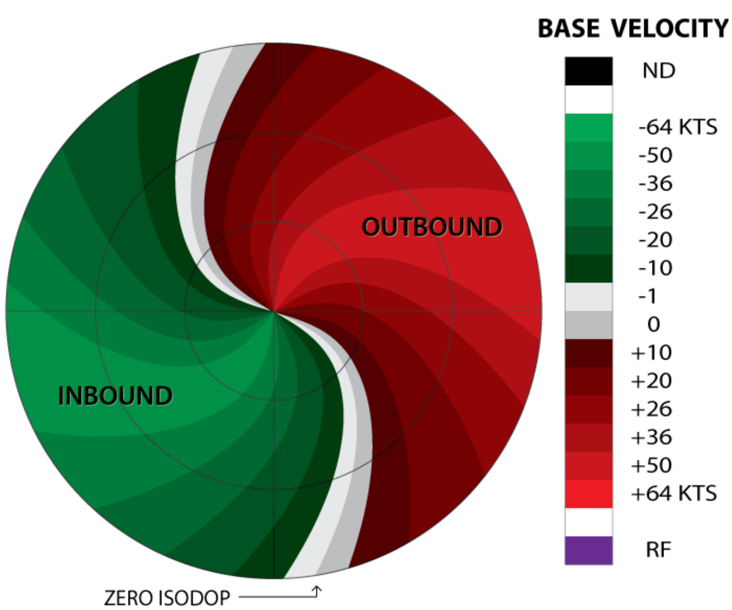


Figure 4-14. "S" shape zero isodop pattern indicating winds veering with height.

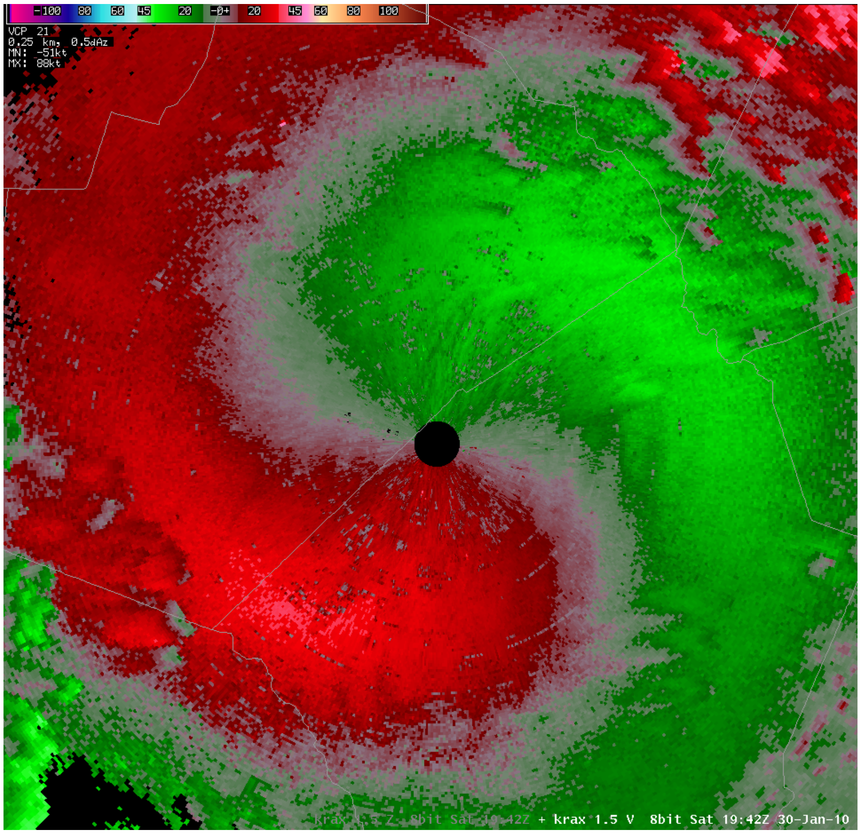


Figure 4-15. Real world “S” shape zero isodop pattern with wind direction veering with height.

Backward “S” Shape

In Figure 4-16, the zero isodop shows some curvature indicating a change in the direction with height. The velocity is from the south at the RDA, from the southeast at the first range ring, and from the east at the edge of the display. The vertical wind profile indicates winds turning counterclockwise from the surface up to the maximum displayed elevation. The meteorological term for this is ***backing***, which usually indicates that cold air advection is occurring.

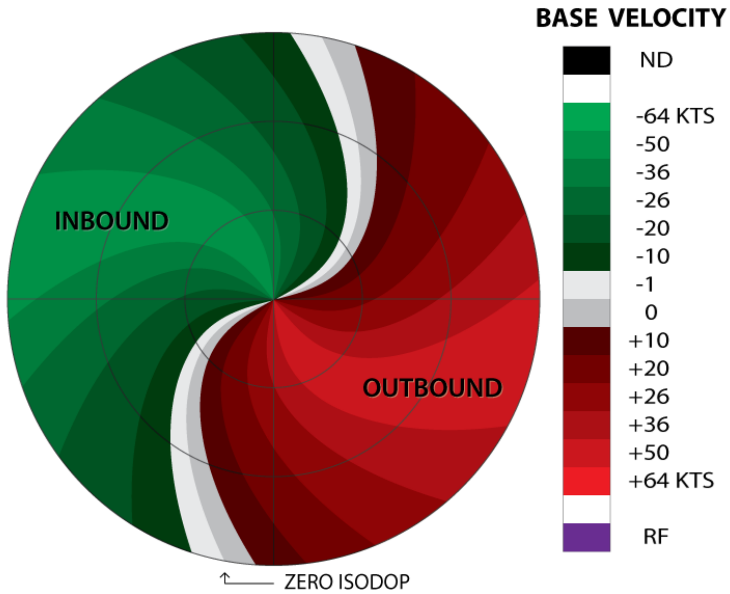


Figure 4-16. Backward "S" shape zero isodop pattern indicating winds backing with height.

Diffluence

In Figure 4-17, the horizontal winds are diffluent at all levels. It is probably easier to interpret this by splitting the display into two parts: the top half and the bottom half.

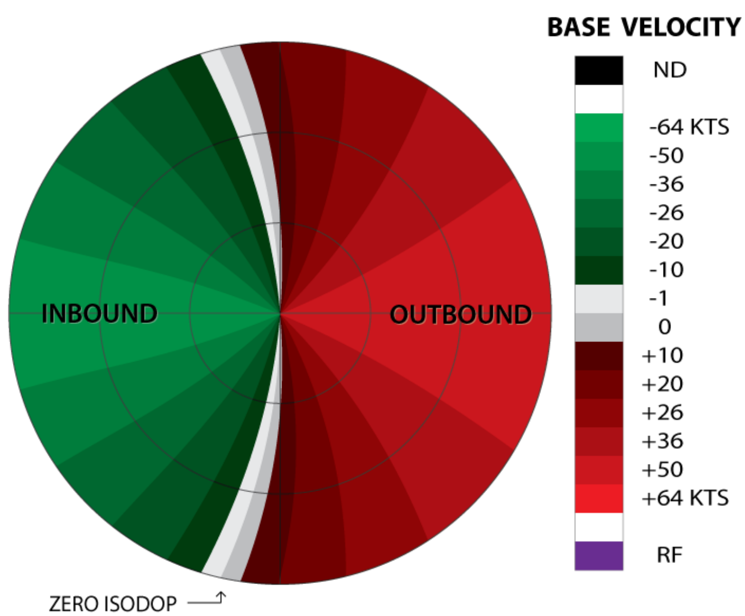


Figure 4-17. A diffluent pattern with the bow-shape zero isodop and the inbound velocities inside the bow.

In the top half, the direction changes from westerly at the surface to southwesterly at the edge of the display. In the bottom half, the direction changes from westerly at the surface to northwesterly at the edge of the display. The associated pattern shows the air spreading out as it passes over the RDA. Note that the zero isodop has a “bowing” shape, and that the ***inbound*** velocities are inside the bow.

Confluence

In Figure 4-18, the flow is confluent at all levels. Notice that the ***outbound*** velocities are on the inside of the “bowing” shape of the zero isodop.

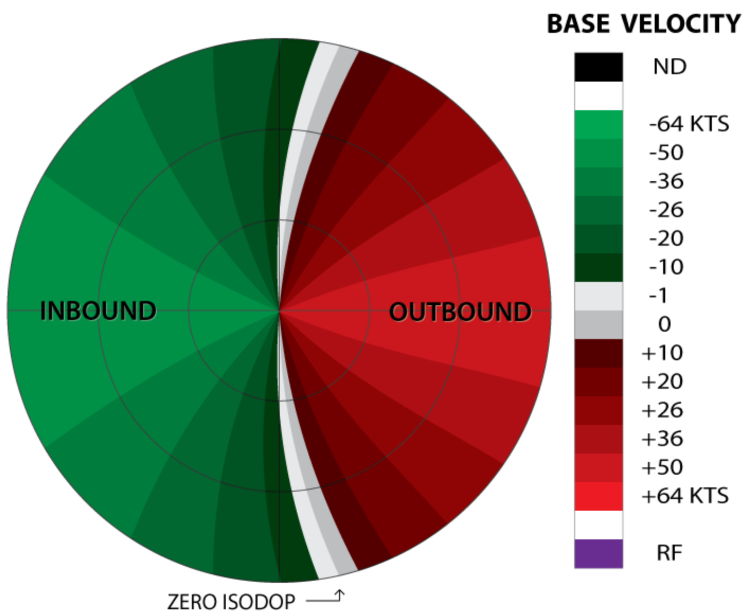


Figure 4-18. A confluent pattern with the bow-shape zero isodop and the outbound velocities inside the bow.

An example of a confluence zone can be seen in Figure 4-19. A lake effect snow band is passing over the radar from southwest to northeast. Note that zero isodop bends in a way that the outbound velocities are “cupped” inside the zero isodop.

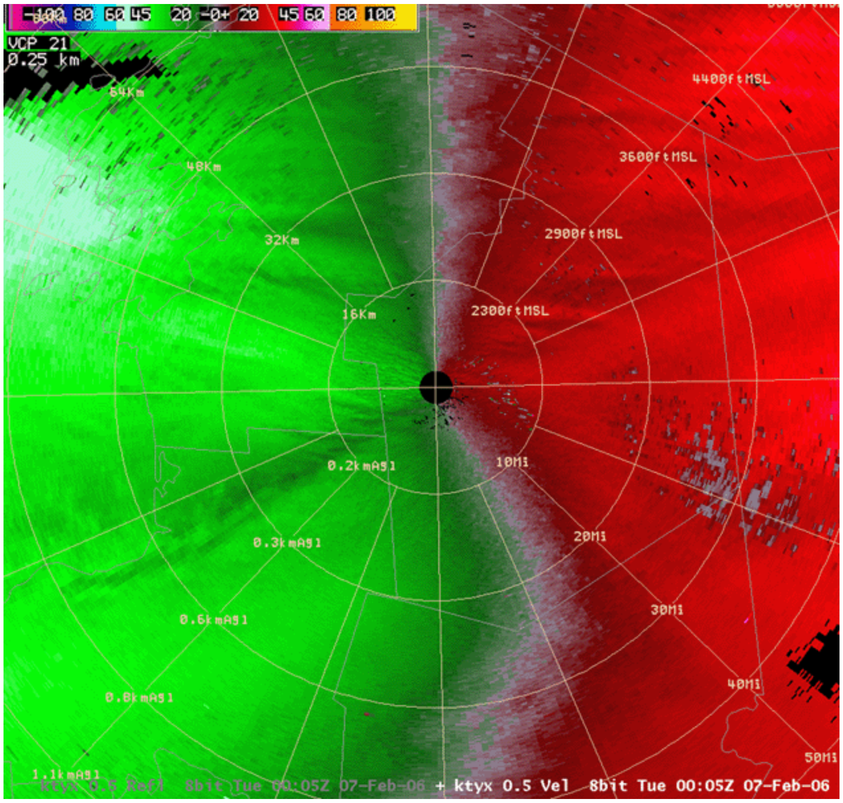


Figure 4-19. An example of a confluent pattern within a lake effect snow band passing over the KTYX RDA.

Sloping Wind Maximum

Figure 4-20 has winds moving from southwest to northeast across the display. Notice the location of the inbound and outbound maxima. The inbound maximum is between the first and second range rings, while the outbound maximum is between the second and third range rings. This indicates that the wind maximum is increasing in height as it moves across the display.

Horizontal Discontinuities/Fronts

In Figure 4-21, there is a frontal boundary located to the northwest of the RDA. Notice that the zero isodop is in a “S” shape over the southeast two-thirds of the display. Velocity maxima are located to the southwest and to the northeast of the RDA. Behind the front, there is another maximum to the northwest. Notice that the northwest maximum does not “connect” with any other maximum.

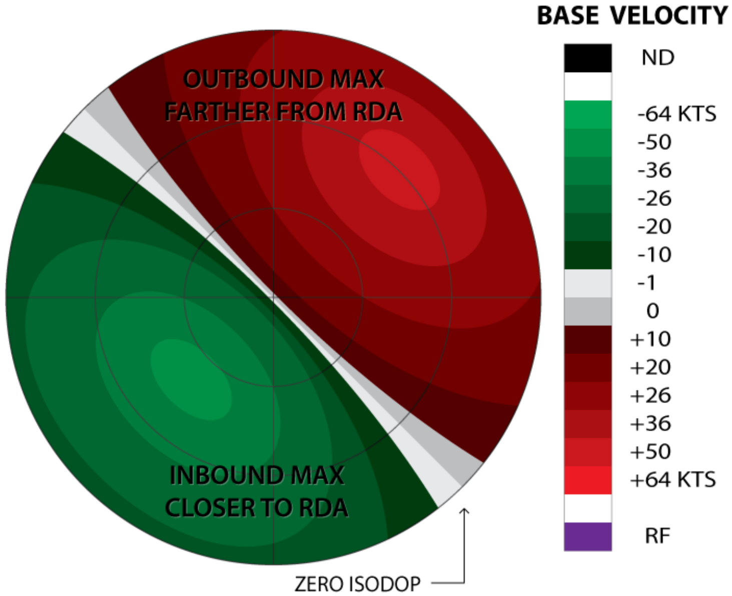


Figure 4-20. Radial velocity pattern for a sloping wind maximum. Note that the inbound and outbound maxima are at different ranges from the RDA. Thus, the maxima are at different heights.

Horizontal Discontinuities/Fronts

Figure 4-22 also has a frontal boundary to the northwest of the RDA. In the real world, it is not always easy to see frontal boundaries, especially in just one volume scan. In this case, try using the loop function.

Ahead of the front, the inbound velocities are from the south-southwest. These correspond with the outbound velocities over the northern half of the display. The location of the front can be found along the cutoff between inbound velocities to the northwest of the RDA and outbound velocities to the north of the RDA. Note that this boundary is being detected aloft.

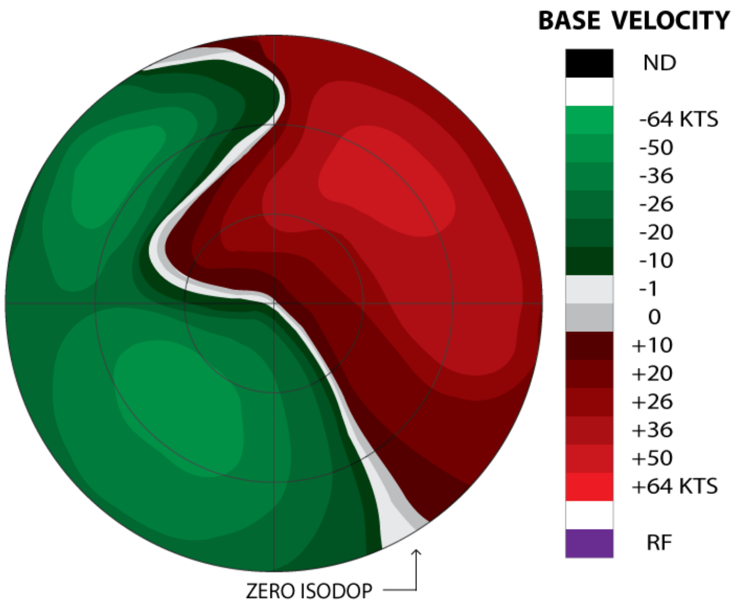


Figure 4-21. A front is located to the northwest of the RDA.

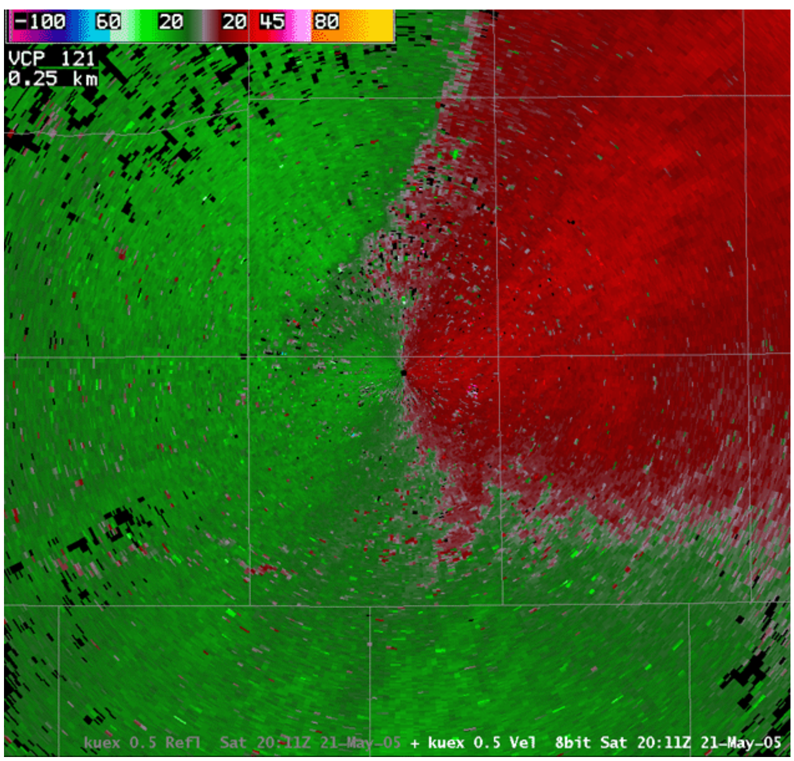


Figure 4-22. Example of a front to the northwest of the RDA.

In Figure 4-23, the frontal boundary is now located from southwest to northeast over the RDA. Winds are from the northwest behind the front and from the southwest ahead of the front.

Figure 4-24 shows an example velocity image with the frontal boundary located over the RDA. Inbound velocities are located to the south and west of the RDA. A sharp change in speeds indicates the location of the boundary.

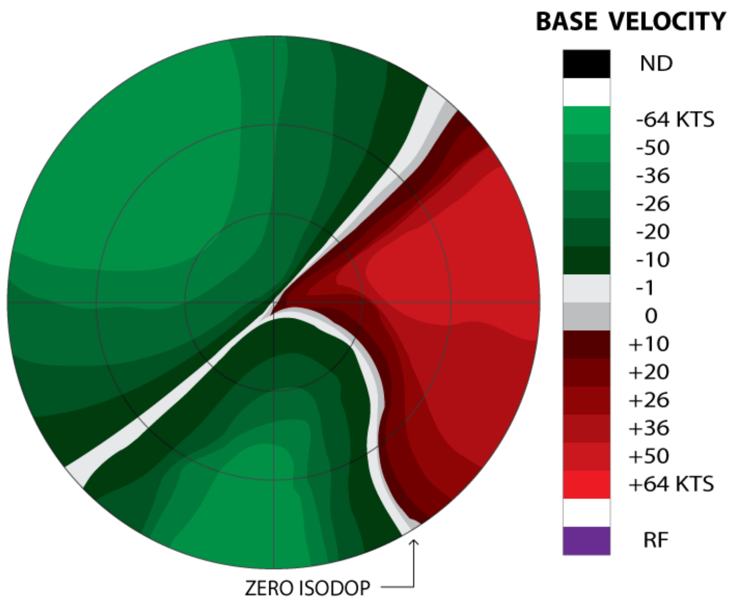


Figure 4-23. A front is located over the RDA.

In Figure 4-25, the front is now located to the southeast of the RDA. The winds ahead of the front are still from the southwest. The frontal boundary is located along the south-southwest to north-northeast oriented zero isodop situated to the south of the RDA and continues to the northeast quadrant of the display. The winds are backing behind the front, as seen with the backward “S” shape pattern of the zero isodop that is centered on the RDA.

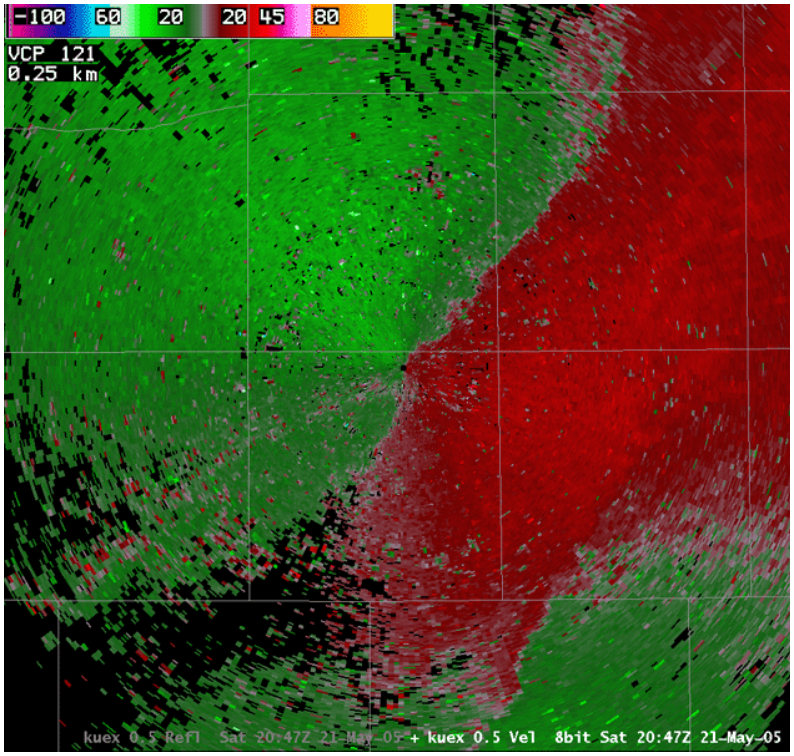


Figure 4-24. Example of a front over the RDA.

Figure 4-26 depicts the front as located along the leading edge of outbound velocities to the east of the RDA. The front then trails in a straight line southwest across the display.

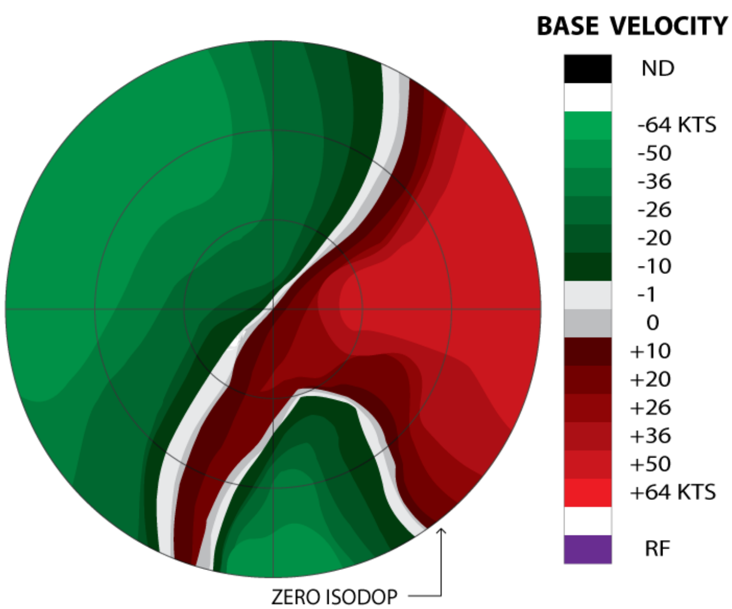


Figure 4-25. A front is located to the southeast of the RDA.

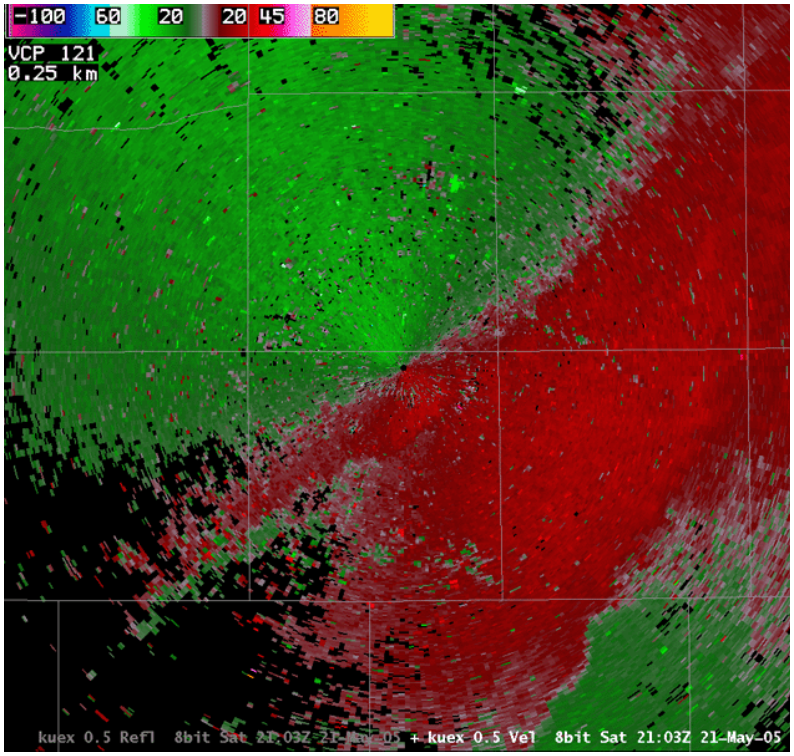


Figure 4-26. Example of a front to the south of the RDA.

Interim Summary

When looking at a display, you are looking into a cone with north at the top of the display.

The full component of the wind will be measured ***only*** when it is parallel to the radial.

When the wind is perpendicular to the radial, ***none*** of the wind is measured.

Inbound velocities are negative and are assigned cool colors.

Outbound velocities are positive and are assigned warm colors.

Wind speed at a particular range (height) is determined by the ***highest Doppler velocity*** at that range if in a homogeneous flow field.

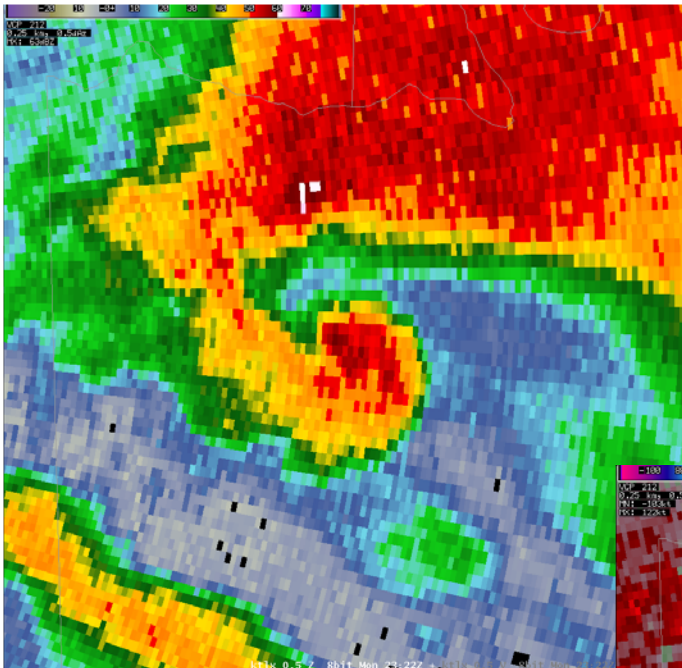
A normal “S” shape zero isodop produces a clockwise turning vertical wind profile (veering), and typically indicates warm air advection.

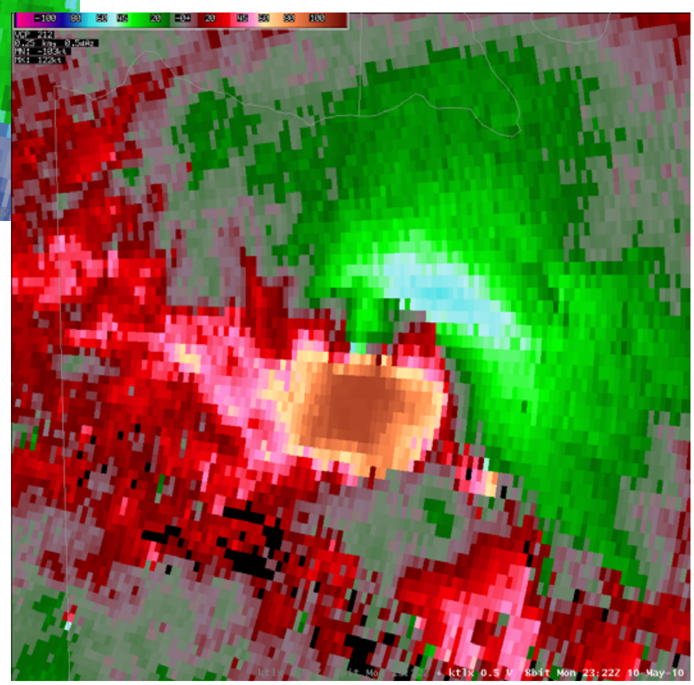
A backward “S” shape zero isodop produces a counterclockwise turning vertical wind profile (backing), and typically indicates cold air advection.

A bow-shaped zero isodop with inbound velocities inside the curve represents diffluence.

A bow-shaped zero isodop with outbound velocities inside the curve represents confluence.

Topic 4: Velocity Interpretation





Lesson 2: Storm-Scale Doppler Velocity Patterns

Presented by the Warning Decision Training Branch

Version: 0910

Lesson 2: Storm-Scale Doppler Velocity Patterns

Review from Topic 3

1. When interpreting velocity products, ***radial*** velocities are displayed, which are ***not*** the true velocities.
2. Improperly dealiased velocities and range folding ***can*** inhibit interpretation of velocity products.

Review from Topic 4 - Lesson 1

1. When looking at a velocity product, you are viewing a conical display from above.
2. The full component of the wind will be measured ***only*** when it is parallel to the radial. When the wind is perpendicular to the radial, ***none*** of the wind is measured.
3. Wind speed at a particular range (height) is determined by the ***highest Doppler velocity*** at that range if in a homogeneous flow field.

Overview

In this lesson, you will learn:

- How to identify convergence and divergence storm-scale velocity signatures.
- How to identify cyclonic and anticyclonic storm-scale velocity signatures.

Objectives

Without references, and in accordance with the lesson, you will be able to:

1. Interpret Doppler velocity patterns under uniform, non-uniform, ambiguous, and meteorologically complex conditions identifying:

   a. Convergence and Divergence

   b. Cyclonic and Anticyclonic Rotation

   c. Any Combination of the Above

2. Assess the mesoscale meteorological conditions and threats associated with the identified velocity patterns.

Interpreting Small Scale Velocity Patterns

In the velocity examples so far, we have examined large scale systems. This next section will deal with small scale phenomena. These phenomena generally cover only a few range gates and therefore have a relatively small change in elevation (see Figure 4-27).

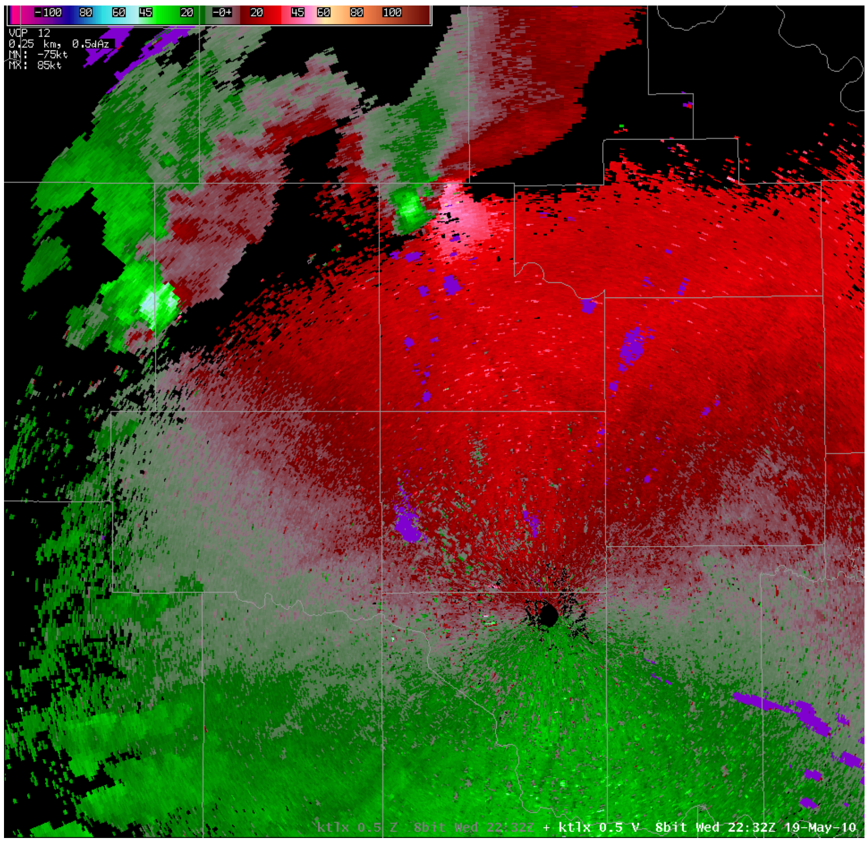


Figure 4-27. Small vs. large scale velocity patterns. Note the large scale zero isodop pattern near the RDA and the individual storms to the north and northwest of the RDA.

Locating the RDA

When examining data on this scale, the operator will be using the zoom feature in order to see small scale rotation and/or convergence/divergence signatures. ***It is critical to know where the phenomena is in relation to the RDA.*** The operator can no longer assume that the RDA is in the center of the display, or on the display at all. The following three points, either used separately or in combination, will help in locating the RDA.

1. Displaying the ***Az/Ran Overlay*** on a velocity product will help determine the location of the RDA by overlaying a polar grid centered on the RDA.

2. Place the cursor at the point of interest and hold down the left mouse button. The ***Cursor Readout*** will give the azimuth and range (in statute miles) from the RDA. Ensure that the Home Location tool is not turned on.

3. ***Range Gates*** increase in width along each radial as they increase in distance from the RDA.

Divergence/Convergence

When interpreting pure divergence or convergence patterns, the velocity maxima lie along the same radial. Whether the pattern is divergent or convergent is dependent on which maximum is closest to the RDA. Note that in the following examples, the RDA is located to the south of the velocity signatures.

Convergence

Velocity maxima lie along the same radial with the ***outbound*** maximum closest to the RDA (Figure 4-28).

Divergence

Velocity maxima lie along the same radial with the ***inbound*** maximum closest to the RDA (Figure 4-29).

Figure 4-30 is a real-world example that shows a divergence signature associated with a circular outflow pattern just after a downburst from a thunderstorm reached the ground. Note that the maximum inbound velocity is closer to the RDA than the maximum outbound velocity.

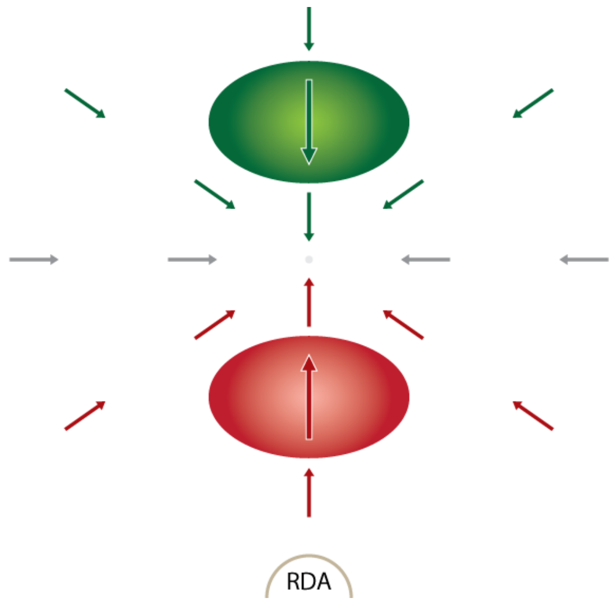


Figure 4-28. Orientation of the inbound/outbound maxima for pure convergence. Note the location of the RDA.

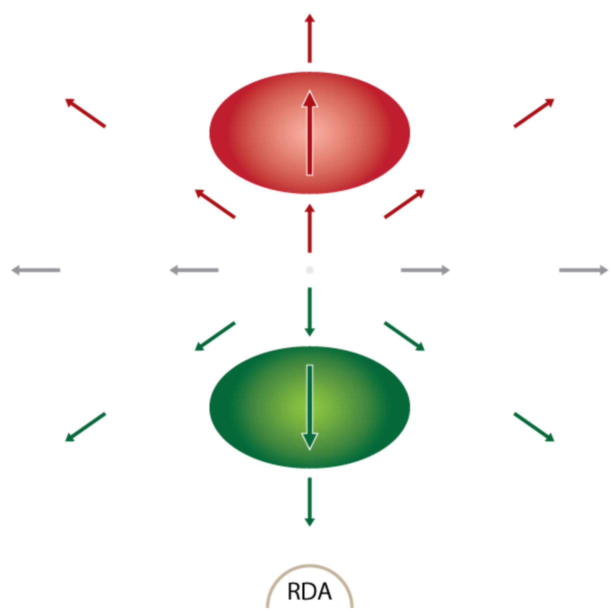


Figure 4-29. Orientation of the inbound/outbound maxima for pure divergence. Note the location of the RDA.

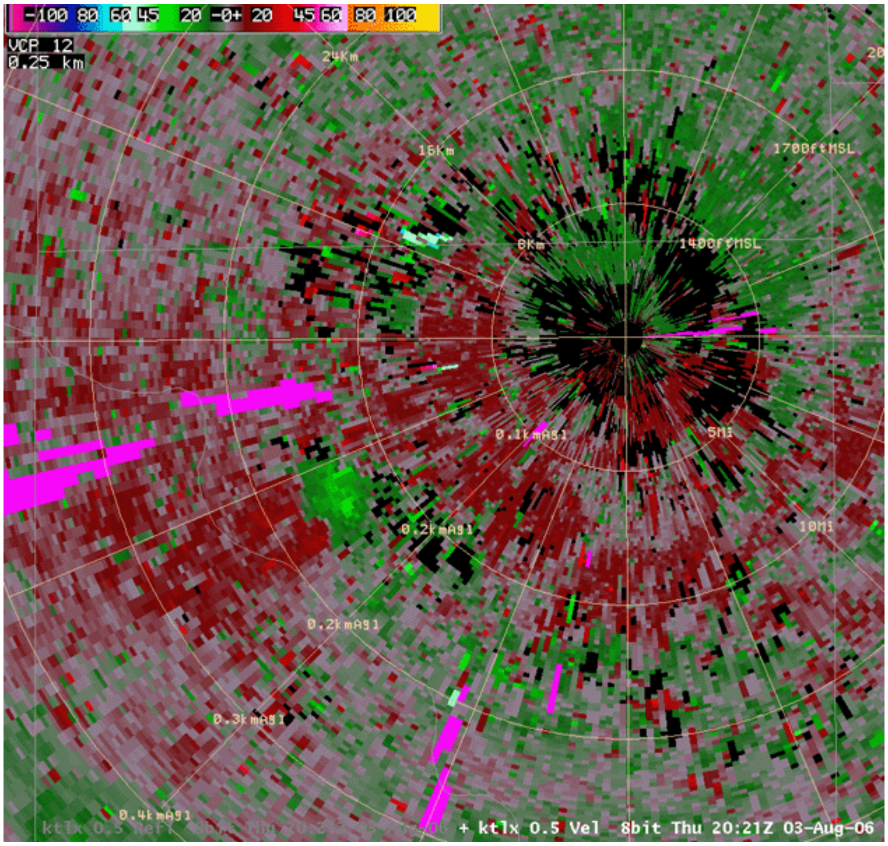


Figure 4-30. An example of a small divergence signature to the southwest of the RDA.

Linear Convergence and Divergence Signatures

Figures 4-28 and 4-29 depict conceptual models of pure convergence and divergence on a ***singular point in space***. Using Figure 4-29 as an example, this model best represents a downburst from a single storm, leading to a circular divergence signature (as seen in the real-world example in Figure 4-30).

However, areas of convergence or divergence can also focus along a ***linear feature***. Figure 4-31 shows a broad area of inbound velocities converging on a broad area of outbound velocities along a linear boundary. In Figure 4-32, the inbound and outbound velocities are diverging from each other along a linear boundary.

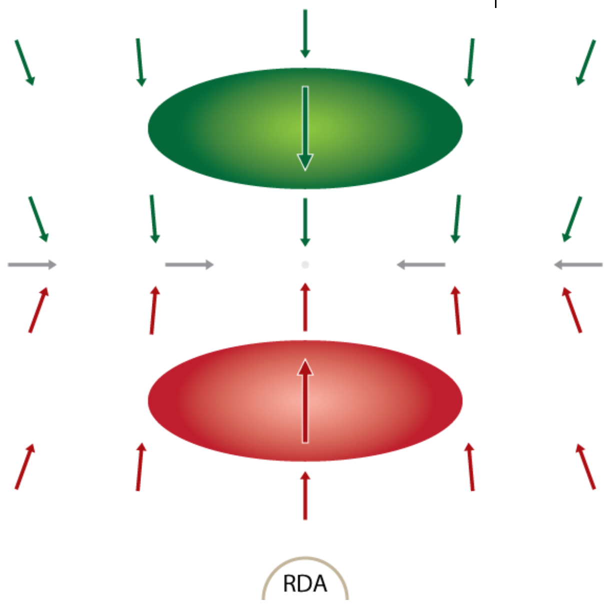


Figure 4-31. Orientation of the inbound/outbound maxima for pure linear convergence. Note the location of the RDA.

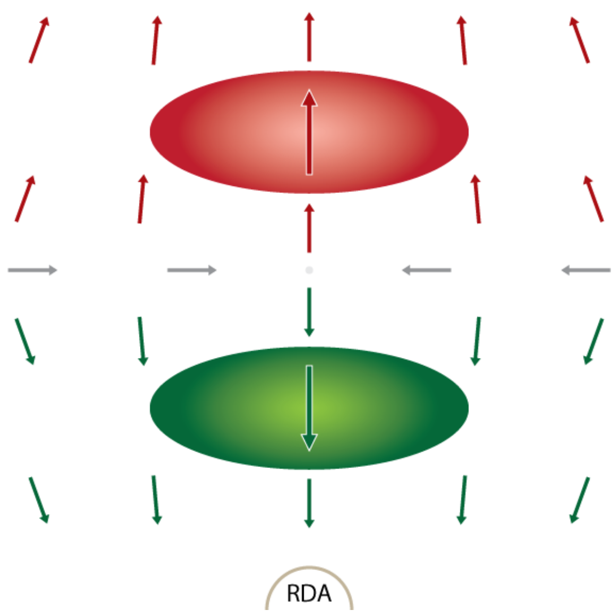


Figure 4-32. Orientation of the inbound/outbound maxima for pure linear divergence. Note the location of the RDA.

In the example shown in Figure 4-33, a linear convergence signal is seen in a bulge along a gust front associated with a line of strong convection located just west of the RDA. Note the north-south elongation of the convergence zone.

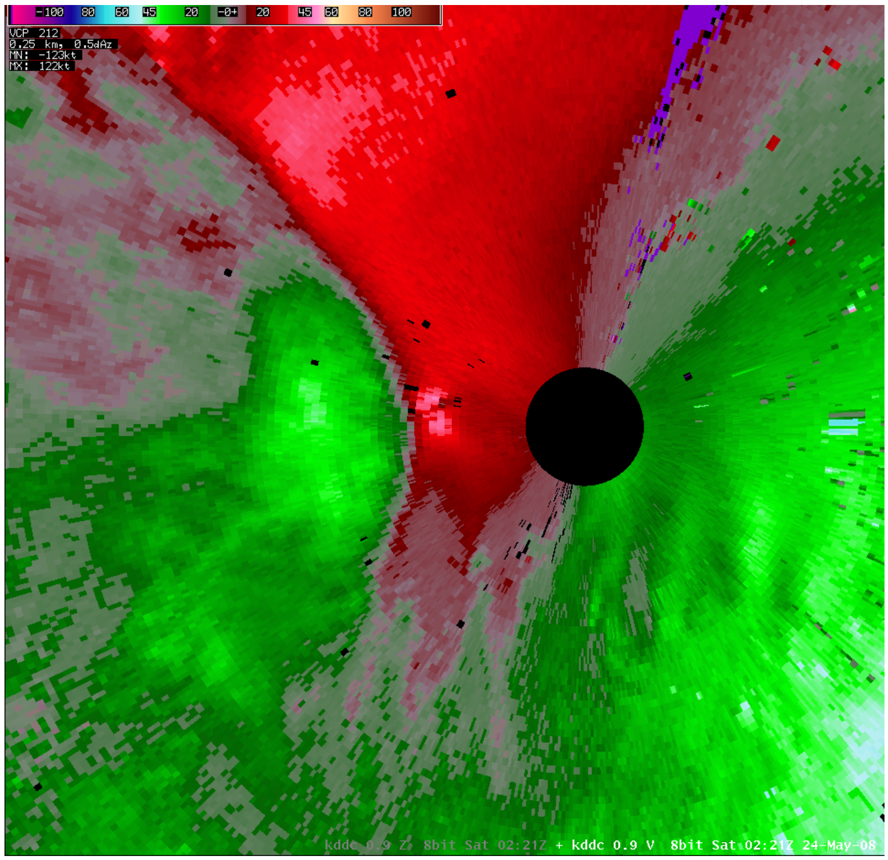


Figure 4-33. An example of a linear convergence signature to the west of the RDA.

Rotation

When interpreting pure rotational patterns, the velocity maxima are equidistant from the radar. Whether the pattern is cyclonic or anticyclonic is dependent on whether the inbound maximum is on the left or the right side of the velocity signature. Note that in the following examples, the RDA is located to the south of the product.

Cyclonic Rotation

With the velocity maxima equidistant, the inbound maximum is ***on the left***, as seen from the RDA (Figure 4-34).

Anticyclonic Rotation

With the velocity maxima equidistant, the inbound maximum is ***on the right***, as seen from the RDA (Figure 4-35).

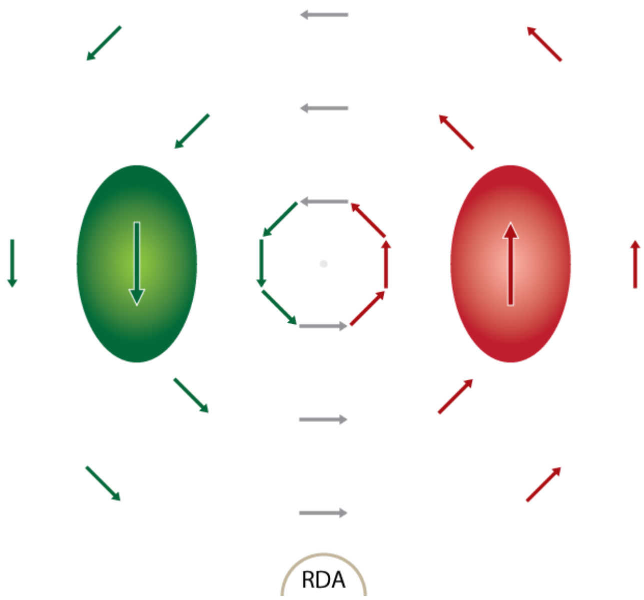


Figure 4-34. Orientation of the inbound/outbound maxima for pure cyclonic rotation. Note the location of the RDA.

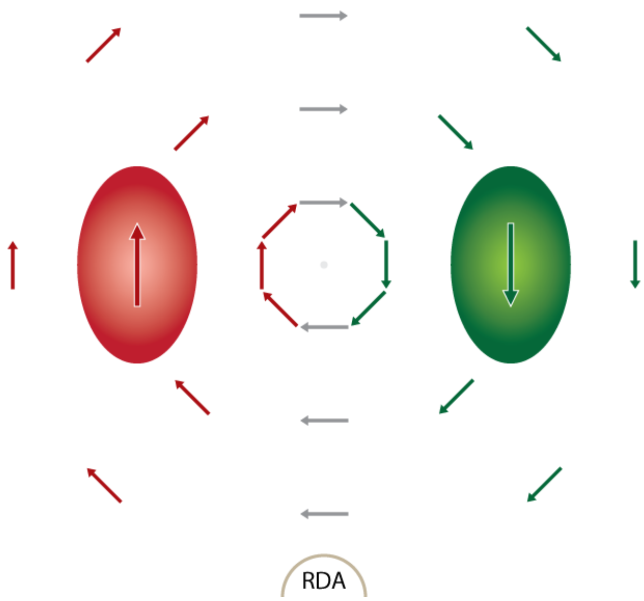


Figure 4-35. Orientation of the inbound/outbound maxima for pure anticyclonic rotation. Note the location of the RDA.

Combinations

In the following examples, the RDA is located to the south of the velocity signatures. The orientation of the velocity maxima from the perspective of the RDA determines convergence or divergence and cyclonic or anticyclonic rotation. In the following examples, the velocity maxima are neither along the same radial nor are they equidistant from the RDA.

As discussed earlier with convergence and divergence, the following signatures can also be focused along a storm-scale linear feature. However, the examples shown here are for signatures that are focused on a single point in space.

Cyclonic Convergence

In Figure 4-36, the outbound maximum is closest to the radar (convergence), and the inbound maximum is to the left (cyclonic), as seen from the RDA.

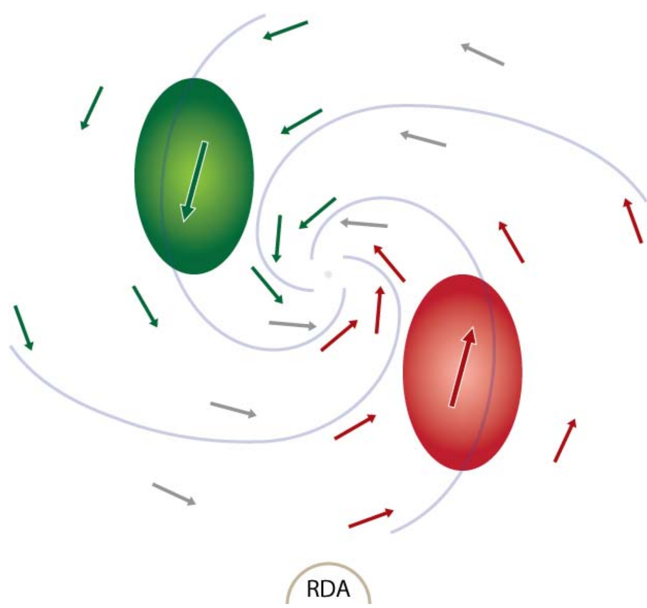


Figure 4-36. Orientation of the inbound/outbound maxima for cyclonic convergence. Note the location of the RDA.

Cyclonic Divergence

In Figure 4-37, the inbound maximum is closest to the radar (divergence) and the inbound maximum is to the left (cyclonic), as seen from the RDA.

Anticyclonic Convergence

In Figure 4-38, the outbound maximum is closest to the radar (convergence) and the inbound maximum is to the right (anticyclonic), as seen from the RDA.

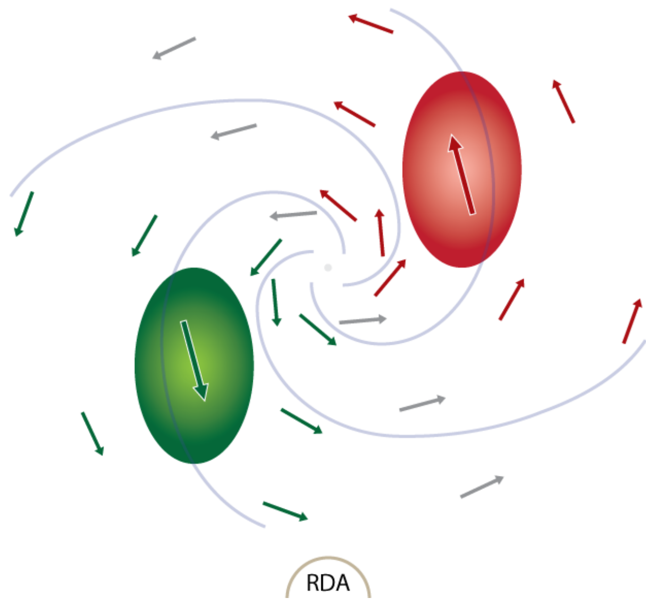


Figure 4-37. Orientation of the inbound/outbound maxima for cyclonic divergence. Note the location of the RDA.

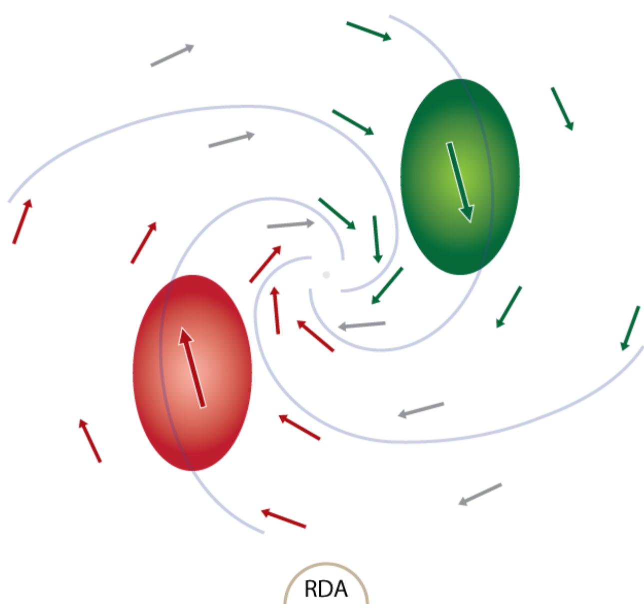


Figure 4-38. Orientation of the inbound/outbound maxima for anticyclonic convergence. Note the location of the RDA.

Anticyclonic Divergence

In Figure 4-39, the inbound maximum is closest to the radar (divergence) and the inbound maximum is to the right (anticyclonic), as seen from the RDA.

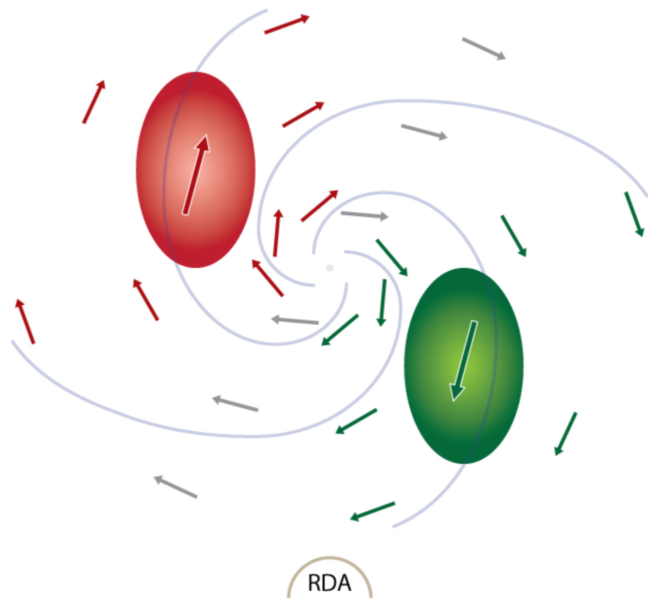


Figure 4-39. Orientation of the inbound/outbound maxima for anticyclonic divergence. Note the location of the RDA.

Example of Storm-Scale Rotation within a Single Storm

In Figure 4-40, the RDA is to the south-southwest of each panel. The upper-left panel (0.5°) depicts cyclonic convergence. Both the upper-right panel (1.8°) and the lower-left panel (3.1°) are close to "pure" cyclonic rotation. The lower-right panel (10.0°) is an example of storm top divergence. Note the tilting of the broad circulation with height and the data quality issues (range folding at 1.8° and improperly dealiased velocities 10.0°).

Sometimes it is easier to view rotation and storm-top divergence within a storm by using the Storm Relative Mean Radial Velocity Map (SRM) product. With this product, the storm motion is subtracted out from the base velocity in order to see the rotation. The SRM will be covered in detail in *Topic 5 - Base and Derived Products*.

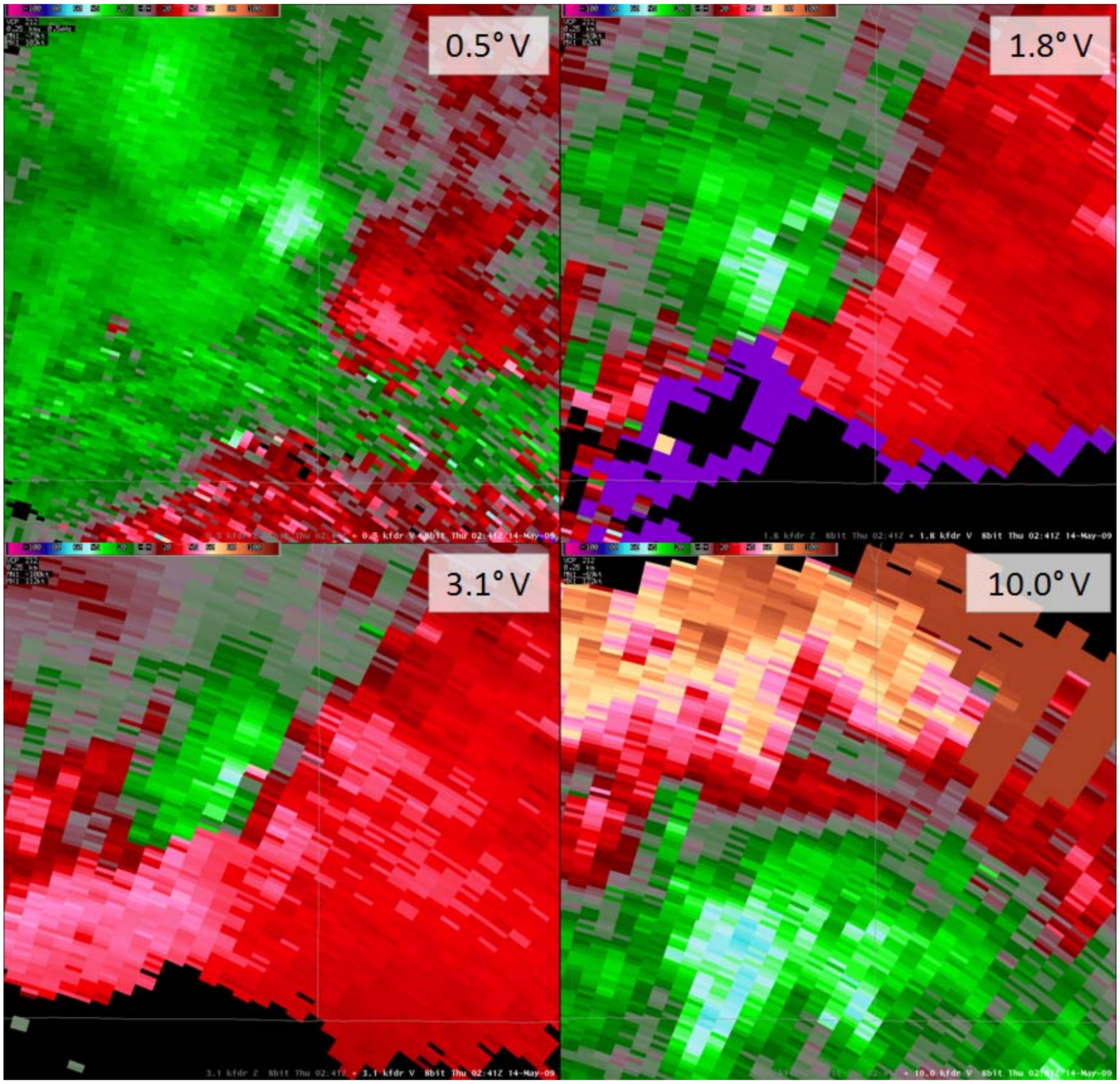


Figure 4-40. Four quadrant display of different elevation angles through a storm. Note that the RDA is to the south-southwest of the display and the small scale features change with height.

Interim Summary

Convergence

The velocity maxima lie along the same radial with the outbound maximum closest to the radar.

Divergence

The velocity maxima lie along the same radial with the inbound maximum closest to the radar.

Cyclonic Rotation

The velocity maxima are equidistant from the radar with the inbound maximum to the left, as seen from the radar.

Anticyclonic Rotation

The velocity maxima are equidistant from the radar with the inbound maximum to the right, as seen from the radar.

Use Figure 4-41 to view how the radar signature characteristic changes with respect to its location to the radar.

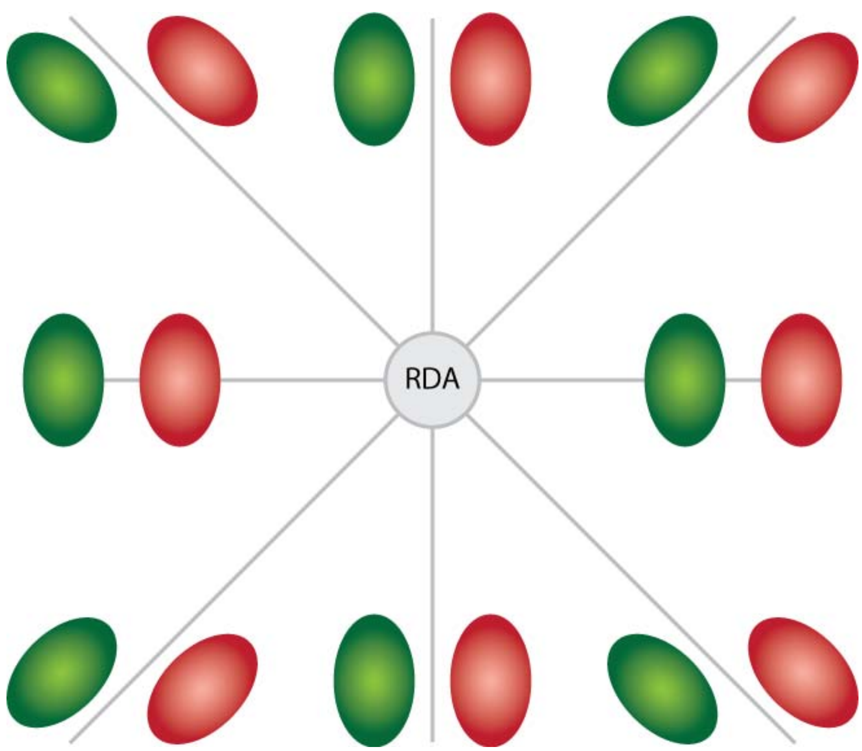


Figure 4-41. Example of how the small scale features change as the radar radial changes.

Review Exercises

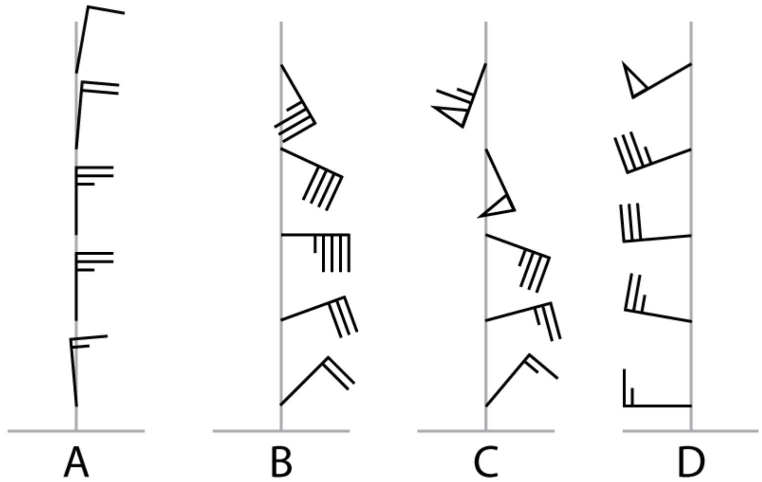
1. Match the wind profiles A through D to the velocity products shown in Figures 1 through 4.

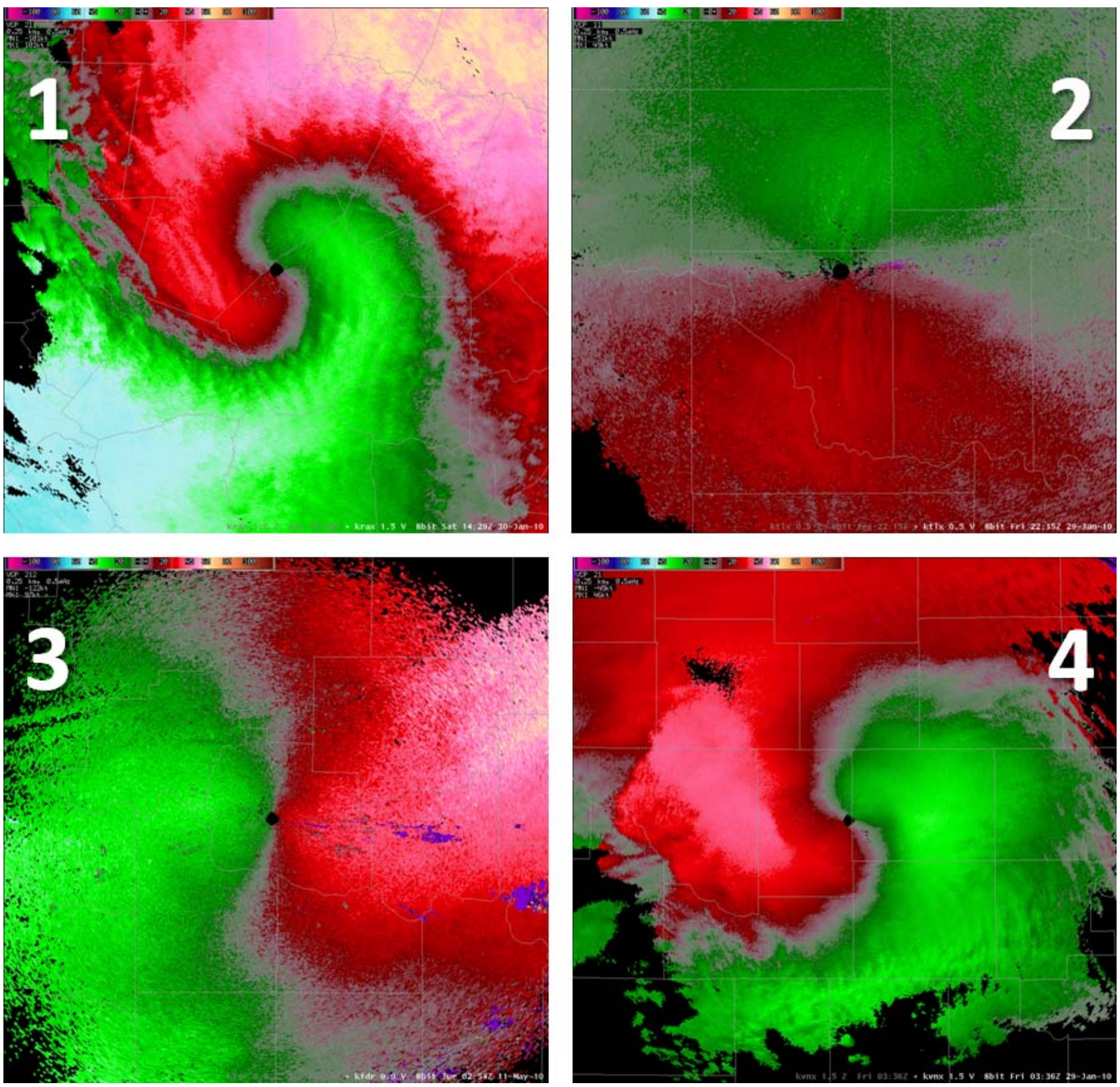
______ A

______ B

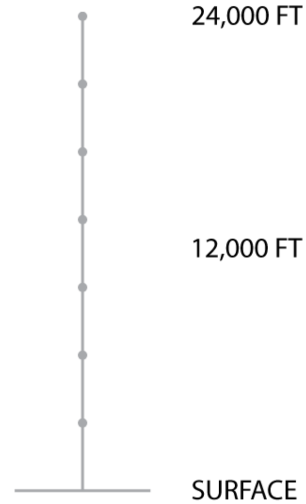
______ C

______ D





2. Construct a vertical wind profile to match Figure 5. (Assume the edge of the display is 24,000 ft.)

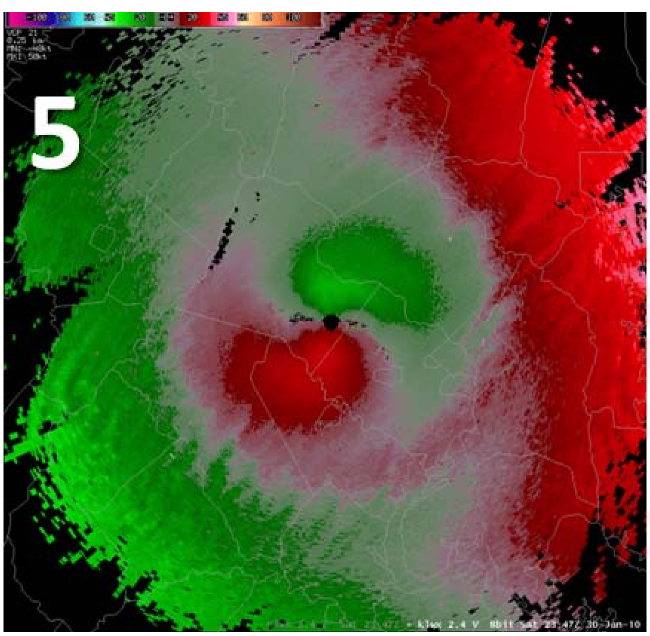


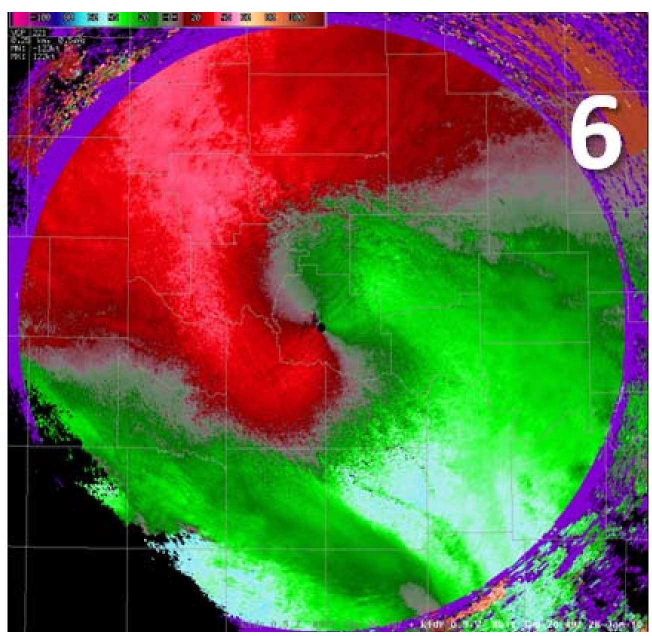
3. In Figure 6, the low level wind direction is from the ______________.

4. In Figure 6, the wind direction at the edge of the display is from the _____________.

5. In Figure 6, the velocity pattern suggests that _____________. Choose the best answer.

a) a frontal boundary is approaching from the southwest
b) a frontal boundary is aloft over the RDA
c) diffluent flow is over the area





6. In Figure 7,

a) What would be the quickest/most accurate way to obtain the range and azimuth of the feature that the arrow is pointing towards using AWIPS?
____

b) Where is the RDA relative to the display? ___________________________

c) The small scale feature that the arrow is pointing towards is _________________. Choose the best answer.

1. cyclonic convergence
2. cyclonic rotation
3. anticyclonic rotation

7. In Figure 8,

a) Where is the RDA relative to the display? ___________________________

b) The small scale feature that the arrow is pointing towards is _________________. Choose the best answer.

1. cyclonic convergence
2. anticyclonic divergence
3. convergence

8. In Figure 9,

a) What would be the quickest/most accurate way to obtain the elevation of the feature that the arrow is pointing towards using AWIPS?
____

b) Where is the RDA relative to the display? ___________________________

c) The small scale feature that the arrow is pointing towards is ___________. Choose the best answer.

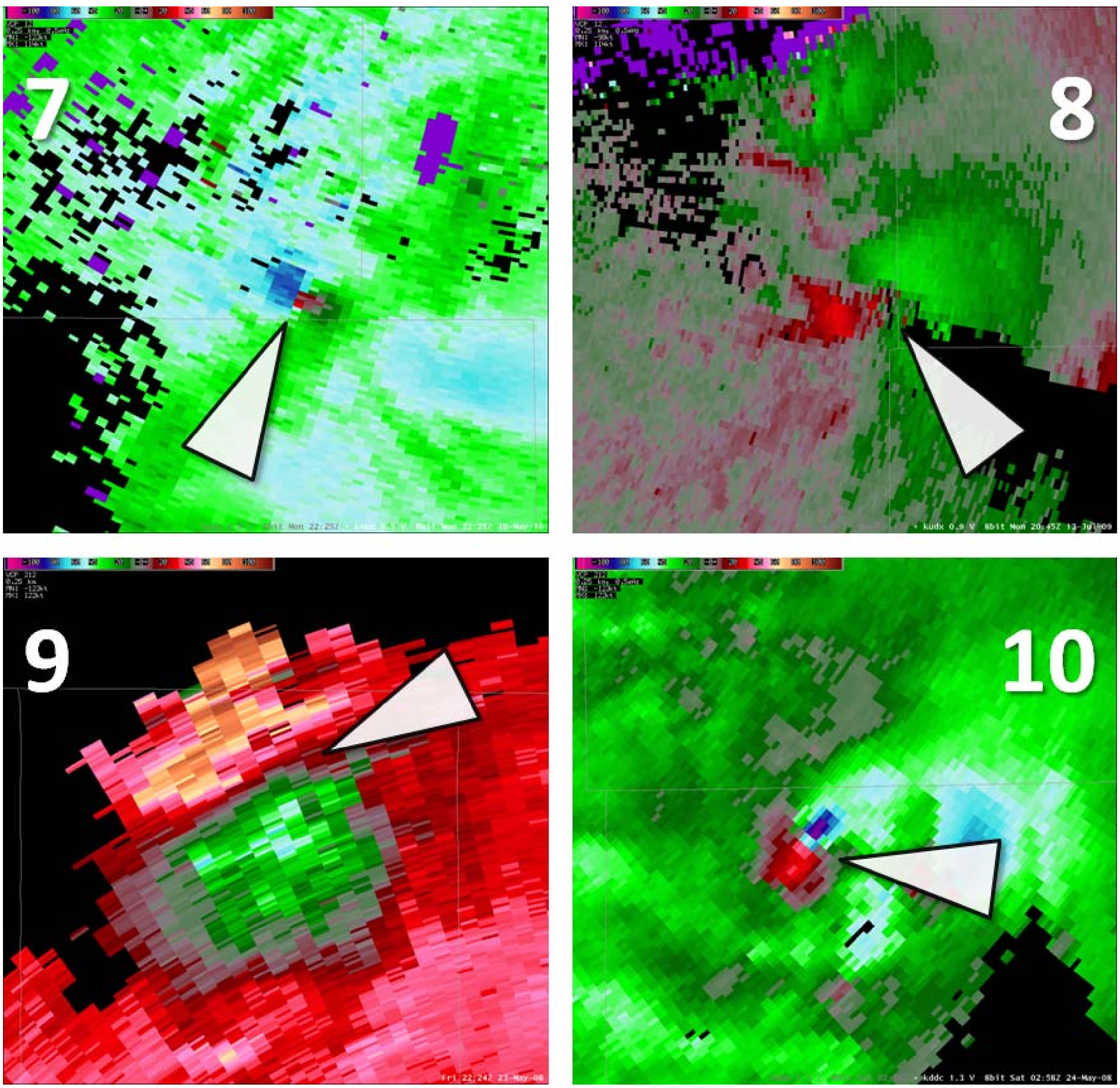
1. convergence
2. divergence
3. cyclonic rotation

9. In Figure 10,

a) Where is the RDA relative to the display? ___________________________

b) The small scale feature that the arrow is pointing towards is _________________. Choose the best answer.

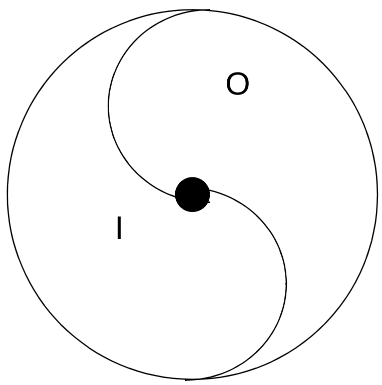
1. cyclonic convergence
2. anticyclonic rotation
3. cyclonic rotation



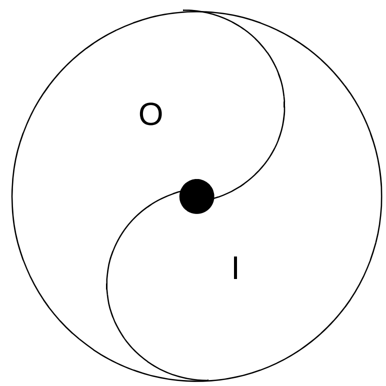
Practice Exercise #1

For each of the following examples, use the zero isodop to determine wind direction at different levels using the method presented in class. The RDA is assumed to be at the center of each circle.

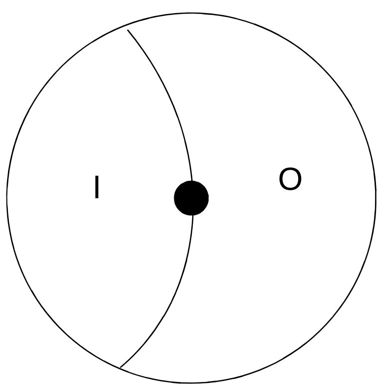
1



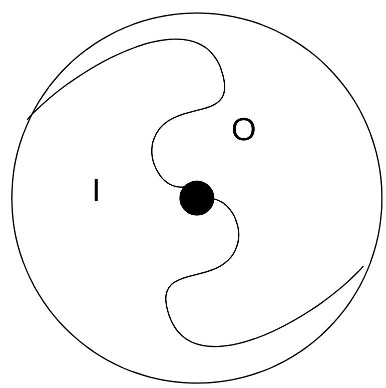
2



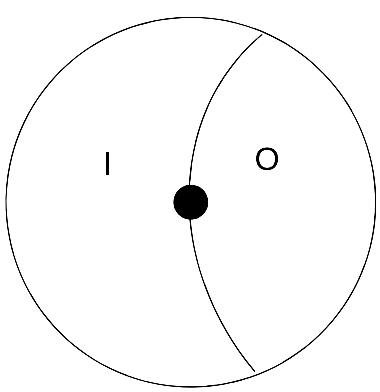
3



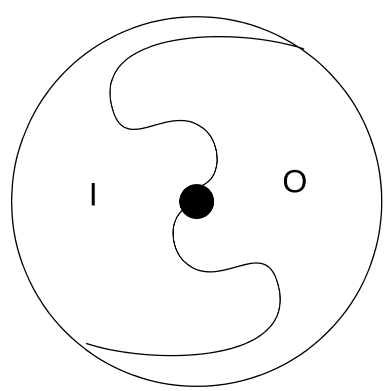
4



5



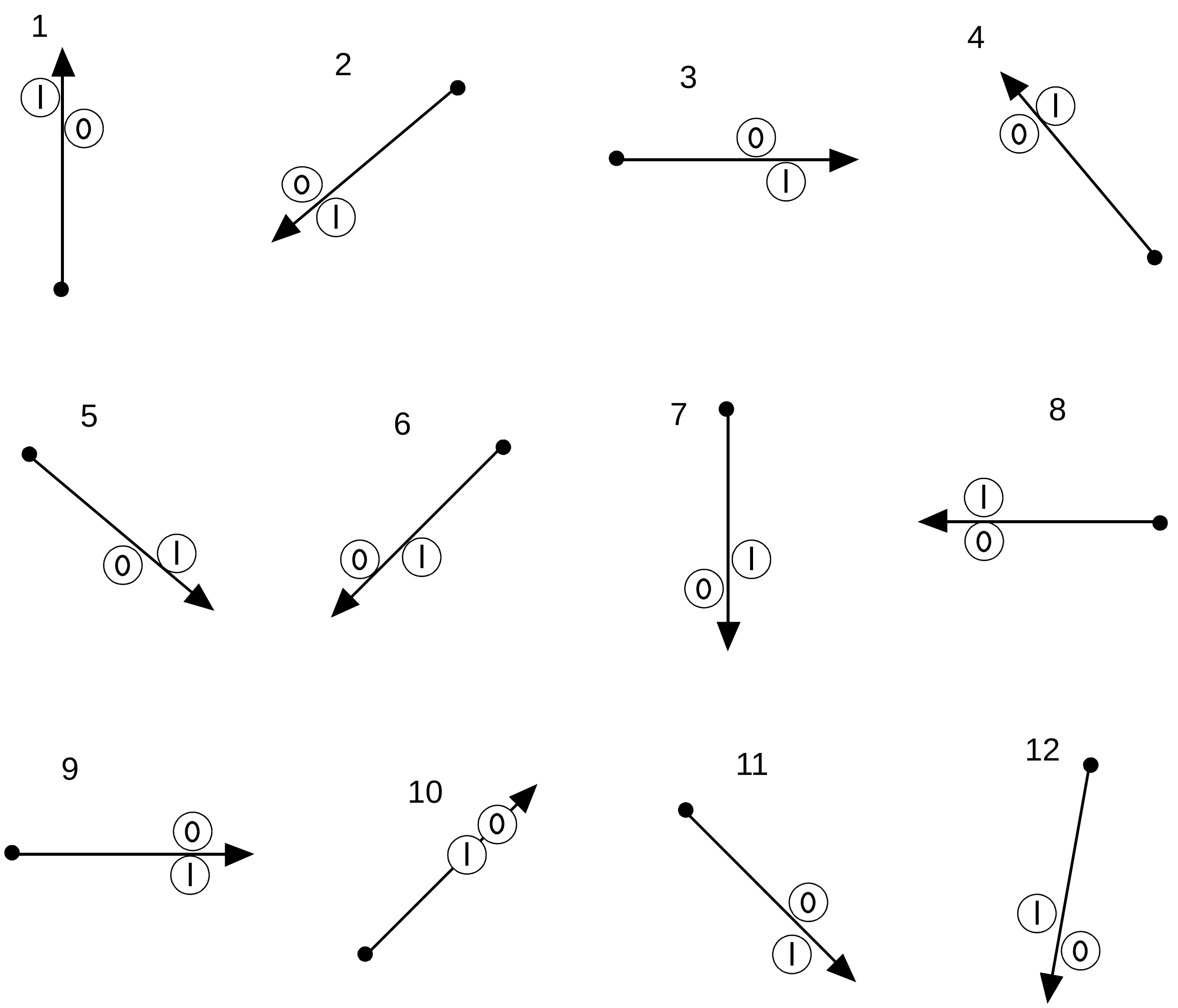
6

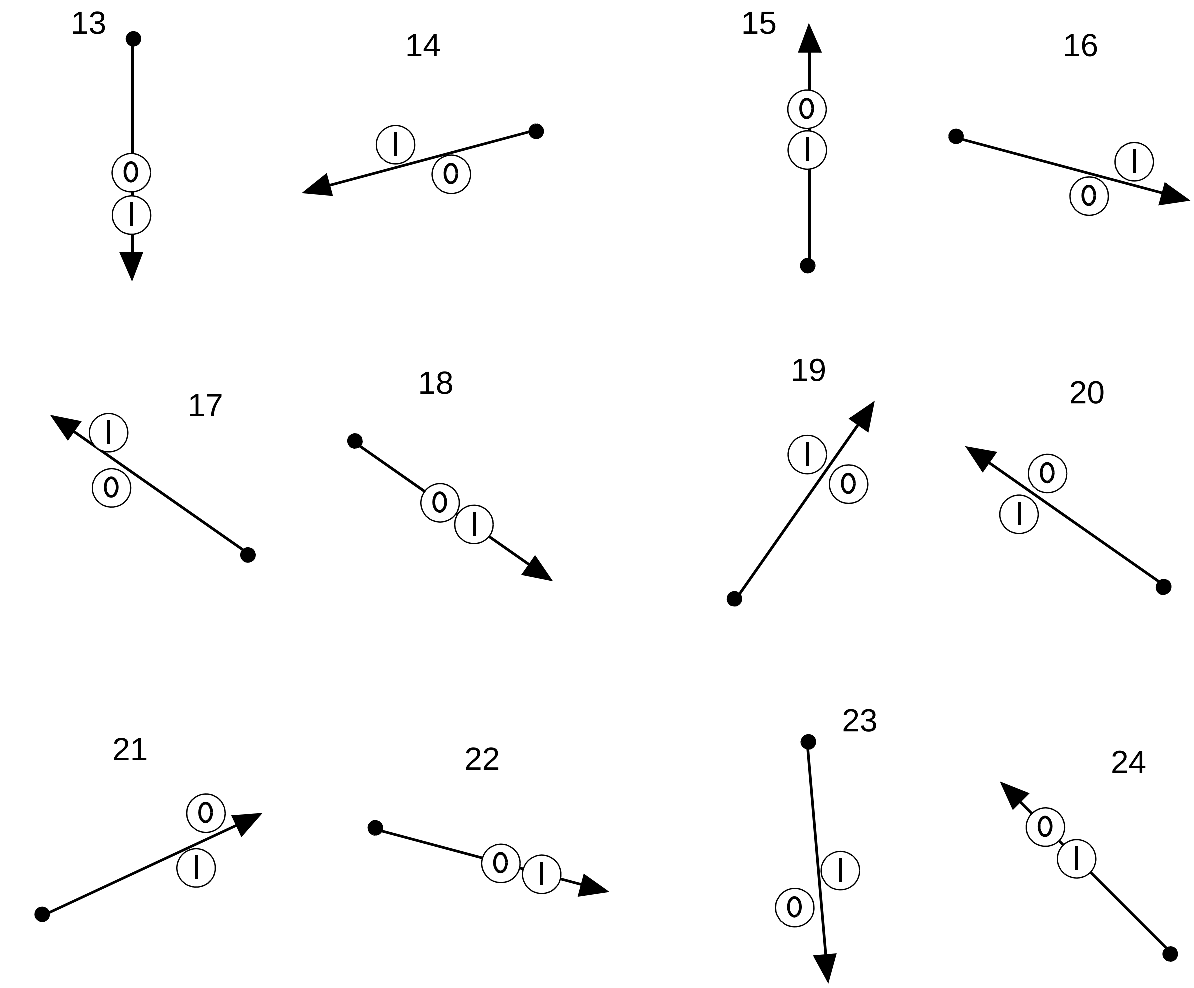


Practice Exercise #2

The velocity couplets below represent small scale patterns. The RDA is located at the dot at one end of the arrow and the arrow is pointed in the direction of the radar beam. The I and O represent the inbound and outbound velocity maxima, respectively. Determine the type of flow pattern and enter the initials on the following answer sheet: Pure convergence (PC), pure divergence (PD), pure cyclonic rotation (CR), pure anticyclonic rotation (AR), cyclonic divergence (CD), anticyclonic divergence (AD), cyclonic convergence (CC), or anticyclonic convergence (AC).

There is a place to write your answers down on the following page.





1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______
10. ______
11. ______
12. ______
13. ______
14. ______
15. ______
16. ______
17. ______
18. ______
19. ______
20. ______
21. ______
22. ______
23. ______
24. ______

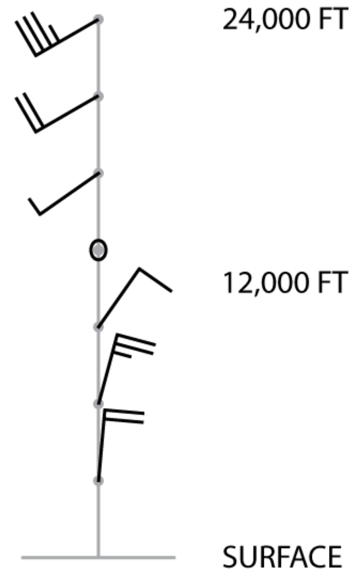
Review Exercises - Answer Key

1. Match the wind profiles A through D to the velocity products shown in Figures 1 through 4.

__***2***__ A __***4***__ B __***1***__ C __***3***__ D

2. Construct a vertical wind profile to match Figure 5. (Assume the edge of the display is 24,000 ft.)

Note: This profile is an approximation. There will be variations in interpretation due to variations in the color copy quality.



3. In Figure 6, the low level wind direction is from the ***northeast***.

4. In Figure 6, the wind direction at the edge of the display is from the ***south-southeast***.

5. In Figure 6, the velocity pattern suggests that _____________. Choose the best answer.

a) a frontal boundary is approaching from the southwest
b) a frontal boundary is aloft over the RDA
c) diffluent flow is over the area

6. In Figure 7,

a) What would be the quickest/most accurate way to obtain the range and azimuth of the feature that the arrow is pointing towards using AWIPS? ***Place the cursor on the point of interest and hold down the left mouse button.***

b) Where is the RDA relative to the display? ***North-northeast***

c) The small scale feature that the arrow is pointing towards is _________________. Choose the best answer.

1. cyclonic convergence
2. cyclonic rotation
3. anticyclonic rotation

7. In Figure 8,

a) Where is the RDA relative to the display? ***West***

b) The small scale feature that the arrow is pointing towards is _________________. Choose the best answer.

1. cyclonic convergence
2. anticyclonic divergence
3. convergence

8. In Figure 9,

a) What would be the quickest/most accurate way to obtain the elevation of the feature that the arrow is pointing towards using AWIPS? ***Place the cursor on the point of interest and hold down the left mouse button.***

b) Where is the RDA relative to the display? ***South-southeast***

c) The small scale feature that the arrow is pointing towards is ___________. Choose the best answer.

1. convergence
2. divergence
3. cyclonic rotation

9. In Figure 10,

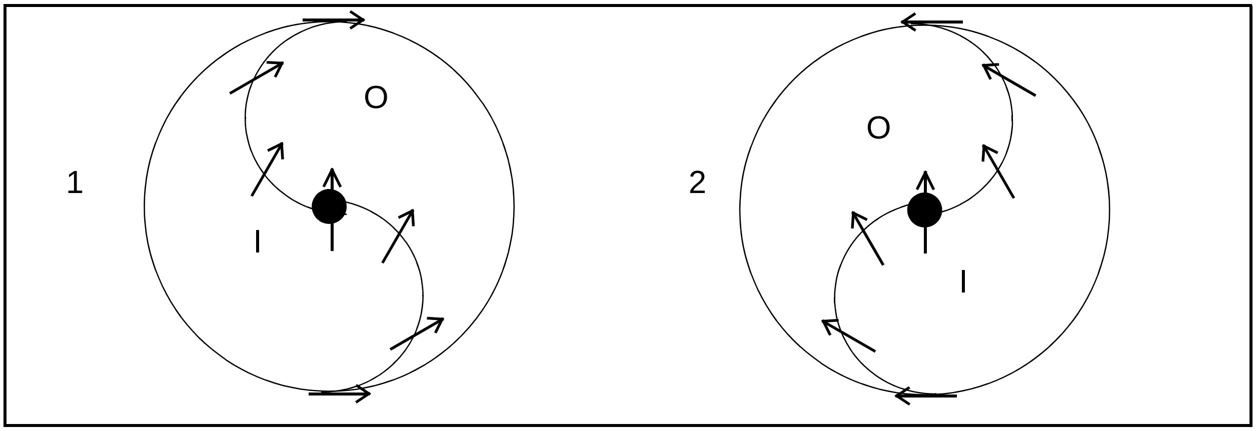
a) Where is the RDA relative to the display? ***Northwest***

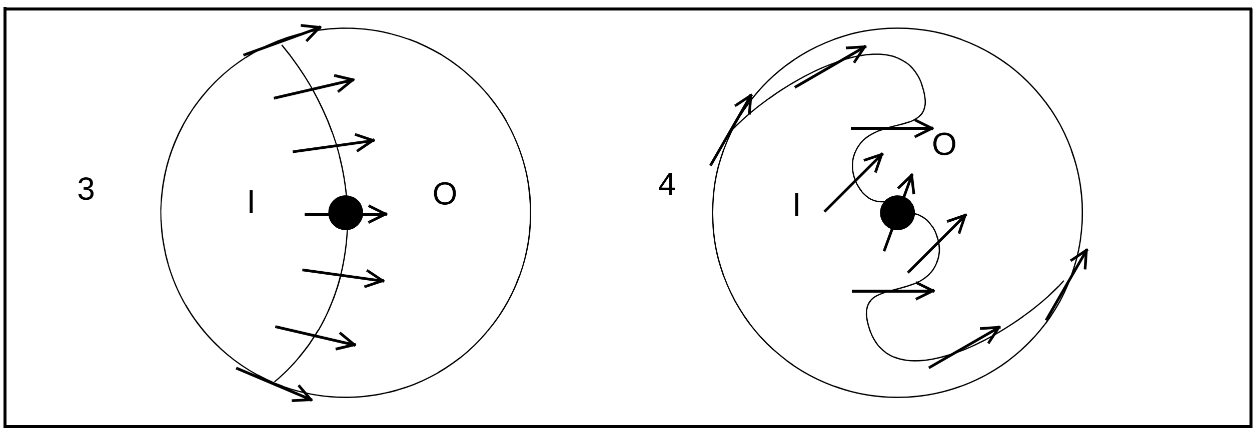
b) The small scale feature that the arrow is pointing towards is _________________. Choose the best answer.

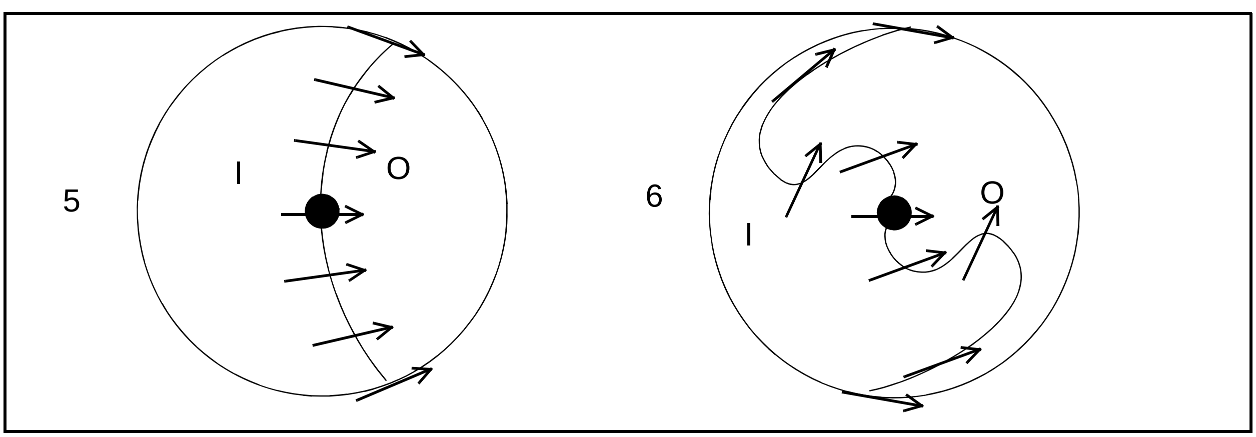
1. cyclonic convergence
2. anticyclonic rotation
3. cyclonic rotation

Practice Exercise #1 - Answer Key

For each of the following examples, use the zero isodop to determine wind direction at different levels using the method presented in class. The RDA is assumed to be at the center of each circle.







Practice Exercise #2 - Answer Key

The velocity couplets below represent small scale patterns. The RDA is located at the dot at one end of the arrow and the arrow is pointed in the direction of the radar beam. The I and O represent the inbound and outbound velocity maxima, respectively. Determine the type of flow pattern and enter the initials on the following answer sheet: Pure convergence (PC), pure divergence (PD), pure cyclonic rotation (CR), pure anticyclonic rotation (AR), cyclonic divergence (CD), anticyclonic divergence (AD), cyclonic convergence (CC), or anticyclonic convergence (AC).

1. ***CC***	7. ***CD***	13. ***PC***	19. ***CR***
2. ***CR***	8. ***AR***	14. ***AC***	20. ***CR***
3. ***AC***	9. ***AR***	15. ***PD***	21. ***AD***
4. ***AR***	10. ***PD***	16. ***CC***	22. ***PC***
5. ***CC***	11. ***AC***	17. ***AC***	23. ***CD***
6. ***CD***	12. ***AD***	18. ***PC***	24. ***PD***